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TRANSACTIONS

OF THE

AMERICAN INSTITUTE

OF

ELECTRICAL ENGINEERS.

REGULAR MEETING, JUNE 17TH, 1890.

SUBJECTS:

Efficiency of Transformers.

BY CALVIN HUMPHREY AND W. H. POWELL,

Notes upon Some Experiments with Alternating Current Apparatus.

BY PROF. HARRIS J. RYAN,

Catalogue of Membership.

REVISED TO NOVEMBER 1st, 1890.

PUBLISHED MONTHLY BY THE INSTITUTE, UNDER THE SUPERVISION OF THE EDITING COMMITTEE.

R. W. POPE, *Secretary*,

12 WEST THIRTY-FIRST STREET.

NEW YORK CITY:

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The 48th meeting of the Institute was held at the House of the American Society of Civil Engineers, 127 East 23d street, New York, June 17th, 1890.

THE PRESIDENT, PROF. W. A. ANTHONY:—The meeting will please come to order. Mr. Crocker has a resolution that he desires to offer.

MR. CROCKER:—I offer the following resolution, which has been recommended by the Council, to the Institute for consideration. The idea is that it shall be taken up for action at our next meeting, which will take place in the Fall. With your permission, I will read the resolution:

Whereas, It has been the custom in the nomenclature of electrical units to perpetuate the names of men who have contributed most to electrical science, and

Whereas, In the names thus far adopted the eminent services of Americans have not been recognized, therefore

Resolved, That in the opinion of the American Institute of Electrical Engineers, a just distribution of the honors thus bestowed necessitates a recognition of the splendid contributions to electrical science of one or both of America's great electricians—Benjamin Franklin and Joseph Henry; and,

Resolved, That this Institute will gladly co-operate with other bodies in this country and abroad to secure the general adoption of these names for electrical units; and,

Resolved, That the name of Henry should be given to the practical unit of self-induction, since he was the discoverer and greatest investigator of this phenomenon, and because this unit at present time is called a quadrant, which is merely a numerical value, and not a suitable name.

Resolved, That this Institute recommend to electrical societies and electrical engineers the general use of the name "Henry" for the unit of induction as being the quickest and surest way to secure its final adoption.

DR. W. E. GEYER: I move that action on this resolution be deferred until the next meeting of the Institute.

MR. MARTIN.—I second the motion.

(Carried.)

THE PRESIDENT.—The next business before the meeting will be a paper on the "Efficiency of Transformers," by Calvin Humphrey and W. H. Powell. This paper will give you the result of some investigations conducted by these gentlemen at Cornell University. The paper will be read by Mr. Powell, and I now have the pleasure of introducing him to the Institute.

MR. POWELL then read the following paper.

A paper read at the 48th. Meeting of the American Institute of Electrical Engineers, New York, June 17, 1890.

EFFICIENCY OF THE TRANSFORMER.

BY CALVIN HUMPHREY AND WILLIAM H. POWELL.

In pursuing this particular line of investigation it has been our endeavor to throw some light, if possible, upon the general subject of transformers and upon the action of iron when magnetized and demagnetized by an alternating current of high peri-

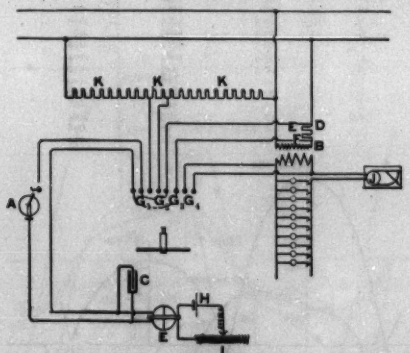


FIG. 1

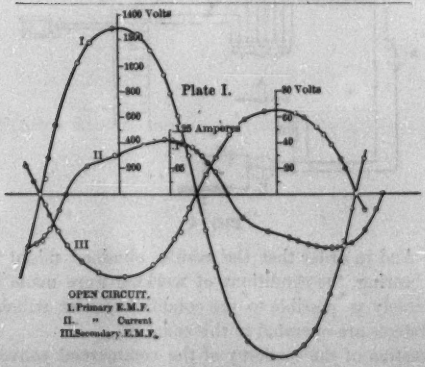
odicity. And in order that the results obtained might have a practical bearing, the conditions of working were made to conform as closely as possible to the conditions under which transformer systems are operated in this country.

The question of the economy of the commercial converter as a transformer of energy has been frequently taken up, both from practical and theoretical standpoints, both with widely varying and conflicting results. The losses in the transformer of the

closed circuit type have been considered large and inevitable, so much so, in fact, that Mr. Swinburne has introduced in England a new form of open circuit transformer known as the "hedge-

OPEN CIRCUIT. PLATE I.

BRUSH.	S. E. M. F.	P. E. M. F.	P. C.
18.5	21. Volts.	450 Volts.	.104 Amperes.
18.2	9.	190	.102
18.	0.	0	.096
17.8	9.	190	.084
17.6	16.5	320	.074
17.3	28.	545	.036
17.	39.	760	0±
16.5	51.5	1020	.0±
16.	59.	1170	.056
15.	65.	1285	.074
14.	61.5	1223	.094
13.5	57.	1130	.102
13.	47.	925	.104
12.7	40.	780	.104
12.4	27.5	565	.102
12.2	20.	330	.098
12.	9.	245	.096
11.8	0.±	70	.088
11.6	0.±	0	.078
11.3	14.	300	.056
11.	27.5	560	.046
10.5	44.	890	0
10.	56.	1105	.03
9.	63.5	1265	.072
8.	63.5	1285	.09
7.5	60 5	1215	.098
7.	53.5	1085	.104
6.7	47.5	945	.110
6.4	40.	810	.110
6.2	29.	610	.108
6.	26.	545	.106
5.8	18	385	.104
5.5	0+	110	.098
5.	14.	260	.074



hog." It has been Mr. Swinburne's endeavor to obviate the dissipation of energy in hysteresis and Foucault currents in a part of the magnetic circuit, by having that circuit closed through

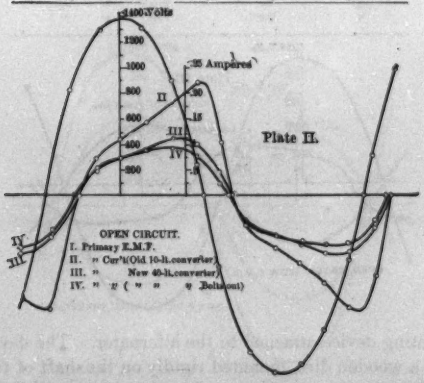
air. But as will be seen later, the perfection of the transformer is to be met in a better grade of iron, rather than in any radical change in design.

The results presented in this paper are of especial interest as being supplementary to the work of Prof. Ryan and Mr. Merritt in the same line, which was presented to the Institute last De-

PLATE II.

Open Circuit (Old 10-lt Converter.) (40-lt Converter. Bolts Out.)

BRUSH.	P. E. M. F.	P. C.	BRUSH.	P. E. M. F.	P. C.
19	825	.196	19	775	.098
18	0	.225	18	0	.089
17	840	.042	17	845	.0
16	1320	.075	16	1245	.048
15	1420	.117	15	1355	.074
14	1345	.143	14	1290	.09
13	1010	.18	13	965	.09
12	230	.22	12	235	.074
11	630	.1	11	590	.0
10	1115	.058	10	1140	.043
9	1395	.1	9	1325	.074
8	1420	.13	8	1312	.09
7	1195	.17	7	1103	.1
6	570	.217	6	520	.1
5	300	.18	5	318	.058
4	1060	0	4	1014	0



cember.[1] The 10-light transformer which they tested was found to have a remarkably heavy loss on open circuit, which was shown to be due almost entirely to hysteresis in the iron. The transformer gave an efficiency of 86 per cent. at normal load and an "all-day" efficiency of about 40 per cent.

In our work on a 40-light transformer of the same design,—

1 TRANSACTIONS, p. 1 *ante*.

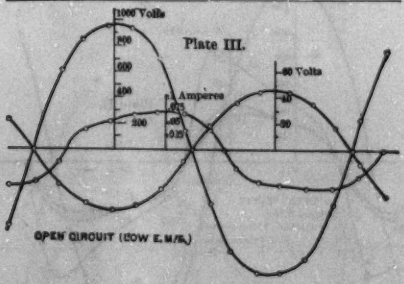
the two coils placed side by side in a core of laminated plates, Fig. 1,—but of more recent manufacture, the loss on open circuit was found to be about one half as great as in the 10-light transformer. Its efficiency reached 96.2 per cent. at normal load, and the "all-day" efficiency would be about 90 per cent.

The method employed in the work is substantially Prof. Ryan's method. The instantaneous values were obtained by means of a

PLATE III.

OPEN CIRCUIT, LOW E. M. F.

BRUSH.	S. E. M. F.	P. E. M. F.	P. C.
19	24.5	595	.07
18	0.	0	.065
17	27.5	580	0
16	42.	890	.04
15	47.	965	.055
14	45.	950	.07
13	33.	715	.075
12	8.	180	.07
11	19.	430	.04
10	39.	835	.07
9	45.	960	.065
8	46.	945	.07
7	38.	8 0	.075
6	16.5	395	.07
5	8.	210	.05
4	35.5	755	0



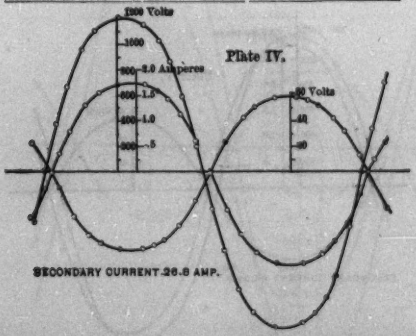
commutating device attached to the alternator. The device consisted of a wooden disc, mounted rigidly on the shaft of the alternator, with a steel contact at one point in its periphery, which made contact with a small piano-wire brush once every revolution. The holder carrying the piano-wire brush was attached to a second wooden disc carrying a pointer which moved over a scale and indicated the position of the brush for a given reading. By means of a clamp screw this second wooden disk carrying the

brush and pointer could be conveniently set at any point. Now since the steel contact in the wooden disc is fixed relatively to the armature, it must share the ever varying E. M. F. of the armature. Then evidently if the brush which completes the circuit

PLATE IV.

SECONDARY CURRENT, 26.8 AMP.

BRUSH.	S. E. M. F.	P. E. M. F.	P. C.
18.5	24.5	370	.82
18.	0.	0	.22
17.5	11.	410	.28
17.	30.5	743	.86
16.5	46.	980	1.25
16.	53.	1110	1.55
15.	59.5	1220	1.76
14.	57.5	1145	1.74
13.5	54.	1045	1.64
13.	47.	850	1.43
12.5	34.	565	1.06
12.	13.	200	.16
11.	21.	575	.58
10.5	37.	850	1.06
10.	47.5	1060	1.44
9.	58.5	1215	1.77
8.	57.5	1195	1.80
7.5	56.	1115	1.66
7.	52.5	995	1.58
6.5	42.	780	1.32
6.	27.	390	.9
5.5	10.	0	.34
5.	0.	325	.16



through the contact be altered in position, values can be obtained for different points on the curves of E. M. F. and current.

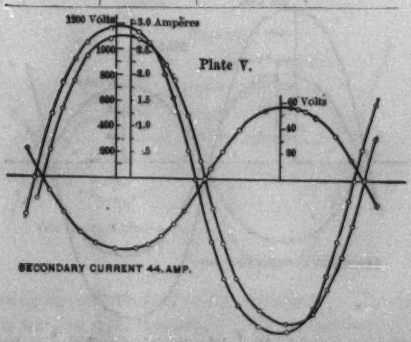
The Ryan quadrant electrometer was used to measure the primary E. M. F., secondary E. M. F. and primary current. A condenser was connected in multiple with the electrometer. The primary current was measured by the fall of potential through

incandescent lamps placed in series with the primary of the transformer. These lamps were carefully calibrated with the standard instruments of the laboratory in order to know their resistance at different temperatures. Then knowing the resistance

PLATE V.

SECONDARY CURRENT, 44 AMP.

BRUSH.	S. E. M. F.	P. E. M. F.	P. C.
19.	22.5	300	1.9
18.	0.	0	.37
17.5	10.	465	.325
17.	26.	745	1.3
16.5	39.	935	1.93
16.	48.5	1075	2.4
15.	55.5	1185	2.77
14.	56.	1150	2.67
13.5	51.	1060	2.58
13.	49.	835	2.3
12.5	47.	625	1.9
12.	35.5	230	1.13
11.5	21.	100	.32
11.	0.	505	.48
10.5	11.	795	1.3
10.	24.5	1015	1.98
9.	40.	1140	2.6
8.	54.	1200	2.84
7.5	57.5	1105	2.77
7.	55.5	1030	2.67
6.5	51.5	805	2.23
6.	45.5	510	1.69
5.5	32.5	130	.97
5.	17.	250	0.



of the lamps, and the potential difference at their terminals, the current flowing at once becomes known.

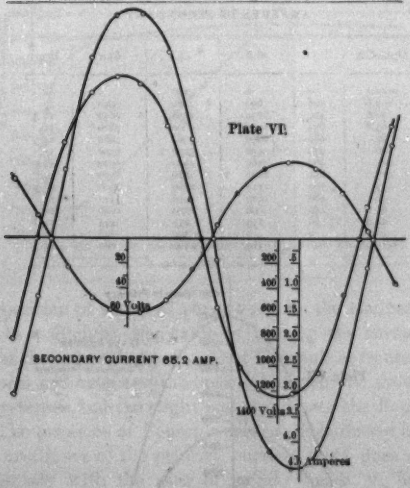
To measure the E. M. F., twenty-two 50-volt lamps were placed in series across the primaries. The electrometer was connected around two of these lamps, and the whole number calibrated in

order to know just what part of the total impressed E. M. F. was measured. The secondary E. M. F. was measured direct. The secondary current was measured by means of an electro-dyna-

PLATE VI.

SECONDARY CURRENT, 65.2 AMP.

BRUSH.	S. E. M. F.	P. E. M. F.	P. C.
19.	45.	745	3.
18.	14.	0	1.08
17.	21.	730	1.23
16.	47.	1120	3.45
15.	58.	1945	4.3
14.	60.	1195	4.35
13.	51.	905	3.8
12.	26.	240	1.85
11.	8.	550	.4
10.	40.	1050	2.9
9.	55.	1225	4.1
8.	59.	1235	4.5
7.	55.	1070	4.25
6.	37.	475	2.83
5.	0.	935	0.
4.	29.	900	2.



mometer, which was carefully calibrated both before and after the experiments and was found to be constant. The commutating device was placed in series with the electrometer. Wires

were run from the terminals from which the measurements were desired to a convenient switch-board. (Fig. 2.)

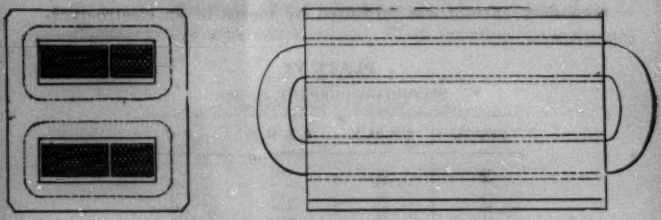


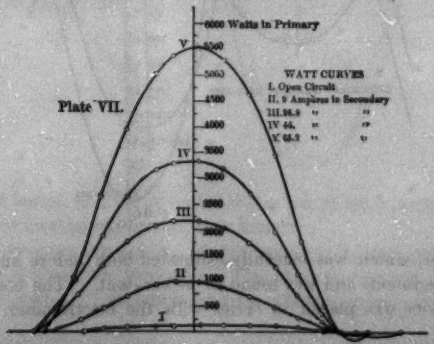
FIG. 2.

It is worthy of mention that this method which gives some thing so definite and fundamental in the treatment of the alter nating current has only come into use within the past year, and

PLATE VII. WATT CURVES.

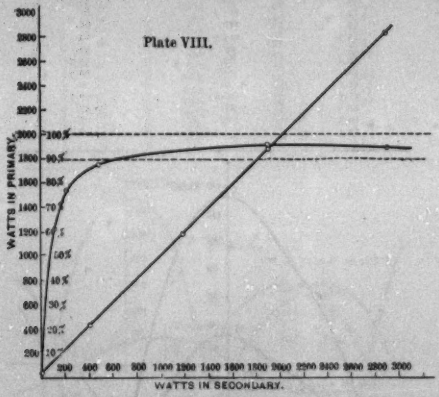
AMPERES IN SECONDARY

Open-Cir.	9.*	26.8	44.	65.2	Brush.
—22.1	0	0	180	0	18.
—7.6	148	630	960	1020	17.
30.6	400	1230	1750	2640	16.5
63.8	695	1790	2600	3820	16.
82.	880	2040	3080	4880	15.5
96.	970	2130	3250	5350	15.
105.	960	2160	3300	5520	14.5
116.	850	2020	3170	5250	14.
113.	700	1715	2700	4600	13.5
96.5	480	1290	1950	3440	13.
65.	230	600	1070	1800	12.5
22.8	50	115	253	443	12.
—10.5	0	0	—350	—96	11.5
—25.2		319	250	290	11.



the task of getting true instantaneous values of the complete waves of E. M. F. and current which has always been considered too tedious for ordinary patience to deal with, was accomplished with ease in this work in forty-five minutes. A calibrated scale for the electrometer readings added very much to the facility with which observations could be taken.

The marked improvement of the 40-light transformer over the 10-light is due, we believe, to an improvement in the magnetic properties of the iron and a fewer number of turns in the coils, made possible by the better grade of iron. In the 10-light transformer Foucault currents were very effectually weeded out by



the interposition of sheets of paper between the laminated sheets of iron; in a 40-light, the oxide of iron on the surface of the plates was the only safeguard against Foucault currents.

The form and extent of the open circuit curves show the loss due to hysteresis and the slight loss also due to the Foucault currents. The presence of Foucault currents is indicated by the fact that the maximum of the primary current wave does not occur simultaneously with the zero of primary E. M. F., but a little before.

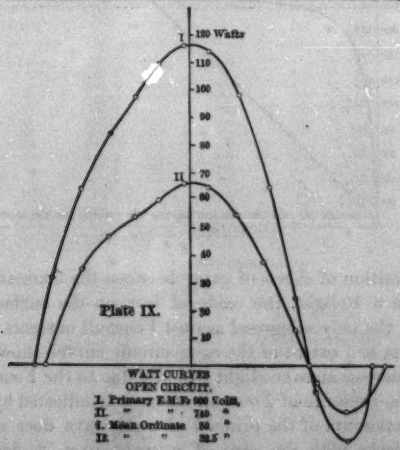
The primary current curve was again taken with the laminated plates loose and free to vibrate. The loss was about 10% less than in the former case (Plate II.) This is thought to be brought

about by the decrease in the hysteresis loss, due to the increase of mechanical shock arising from the free vibration of the plates. The vibration was very perceptibly increased. The curve obtained is more regular in form indicating less hysteresis loss.

PLATE IX.

WATT CURVES. OPEN CIRCUIT.

No.	990 VOLTS.	740 VOLTS.
16.9	0.	
16.7		0.
16.5	30.5 Watts.	11.5
16.	64.	34.
15.5	82.	46.5
15.	96.	53.5
14.5	111.5	61.
14.	116.	66.
13.5	113.5	64.
13.	97.	54.
12.5	65.	35.5
12.	23.	12.5
11.7	0.	0.
11.5	—10.5	—7.5
11.	—25.	—17.
10.5	0.	7.
10.3		0.



The lag of the primary current behind the primary E. M. F. is seen to be greatest when the secondary circuit was open and decreases as a non-inductive load is introduced into the secondary circuit. This tendency of the lag of the primary current to de-

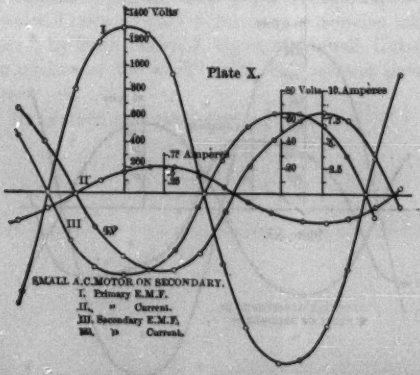
crease with increase of load, continues until the curve of primary current comes into unison with the curve of secondary E. M. F.

The secondary E. M. F. is in unison with the primary E. M. F. on open circuit and gradually falls behind as the load increases on the secondary. This is doubtless due to the leakage of lines of force arising from the enormous magnetizing forces at work in

PLATE X.

SMALL ALTERNATING CURRENT MOTOR ON SECONDARY.

BRUSH.	S. E. M. F.	P. E. M. F.	P. C.	S. C.
19	30.	780	·53	7·36
18	0.	0	·35	4·48
17	40.	790	0	0.
16	60.	1195	·25	3·52
15	64.	1310	·43	6.2
14	61.	1240	·53	7·5
13	46.	930	·54	7·5
12	11.	140	·42	5·76
11	26.	570	·12	0.
10	55.	1115	·14	2·89
9	63·5	1305	·375	4·47
8	63·5	1310	·50	7·20
7	53·	1095	·55	8·32
6	27·5	560	·49	7·20
5	14·	290	·25	3·52
4	47·	950	·0	0.



opposition to one another in the primary and secondary circuits.

When an inductive resistance is introduced into the secondary circuit, the lag of the primary current is greatly increased, as shown by the set of curves in Plate X. The inductive resistance used in this case was due to a small alternating current motor. The curve of secondary current was also taken and found to lag

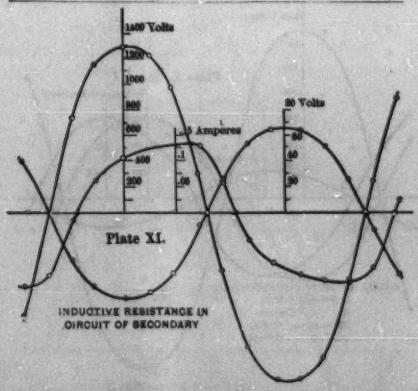
behind the secondary E. M. F. and to be in unison with the primary current. About 5.5 amperes flowed in the secondary and yet the lag of primary current is as great as on open circuit.

Plate XI shows the relation of primary current and primary E. M. F. when the secondary was closed through the secondary of a 20-light transformer whose primary remained open. The current

PLATE XI.

INDUCTIVE RESISTANCE OF SECONDARY.

BRUSH.	S. E. M. F.	P. E. M. F.	P. C.
19	39.	790	.147
18	0.	0	.126
17	40.	770	0
16	61.	1185	.066
15	67.	1310	.108
14	63.5	1245	.126
13	48.5	950	.135
12	11.	230	.135
11	26.	515	.06
10	56.	1105	.05
9	66.	1315	.099
8	65.5	1295	.12
7	56.	1105	.126
6	26.	545	.126
5	14.	280	.108
4	48.	950	0



curve shows a distinctive lag from the inductive resistance and is altered in form to a great extent.

In Plate IX will be seen the watt curves for open circuit loss, one for 990 volts and the other for 740 volts. From the value of the mean ordinates it is seen that the loss varies strictly as the square of the impressed E. M. F.

In Plate II is plotted to the same scale the current which flowed on open circuit in the case of the 10-light transformer and the 40-light transformer.

Plates IV, V, and VI show the curves of primary E. M. F. and current and secondary E. M. F. for different loads, from which the watt curves of Plate VII. are computed by taking the product of corresponding ordinates of primary E. M. F. and current.

The efficiency curve shown in Plate VIII. is the ratio between the energy of the primary circuit as indicated by the mean ordinate of the watt curve, and the energy of the secondary circuit as expressed by the product of the $\sqrt{\text{mean}^2}$ readings for E. M. F. and the current. The coercive force is equal to .8 C. G. S.

These considerations go to show that the loss due to the reversal of polarity of the iron, which perhaps must always be present may be reduced almost indefinitely by a proper study of the magnetic properties of the iron used.

The President.—As the next paper touches upon the same subject we will have it read before any discussion takes place. The paper is by Prof. Harris J. Ryan, of Cornell University. It is in continuation of the work which the Professor gave to you last winter.

Prof. Ryan then read the following paper :

A paper read at the 98th Meeting of the American Institute of Electrical Engineers, New York, June 17th, 1890.

SOME EXPERIMENTS UPON ALTERNATING CURRENT APPARATUS.

BY HARRIS J. RYAN.

It is well known that when the core of a transformer is heated under certain favorable conditions, the secondary will deliver electrical energy in amount considerably greater than when the core is not heated, and that this is done, too, without an increase of the energy that is supplied to the primary. In fact, we are told that on heating the core of the properly constructed transformer that there will follow a diminution of energy taken up by the primary and a considerable increase in that given out by the secondary.

In some recent experiments made in the Physical Laboratory of Cornell University, it was not possible to obtain the above effect. Mr. L. B. Marks, a student in electrical engineering at Cornell, made an apparatus that differed materially from the forms that were first made use of in which he found this phenomenon very marked.

For two reasons do we think that the details of the performance of Mr. Marks's apparatus will be of interest to the members of the Institute—first, that they indicate clearly the source of energy in the phenomenon observed with his apparatus, and second, that they show in exaggerated form certain phenomona that must be done away with in a transformer that is to be used for incandescent lighting.

A good idea of the apparatus will be obtained by a glance at Fig. 1. The core consisted of nine well-rusted rings 1.1 cms. thick and of a mean diameter of 17 cms. each. The number of turns on the primary was 500; on the secondary 155; size of bare copper wire in each was No. 18 B. & S. gauge. The wire

was insulated with asbestos paper, and because of its thickness, the primary and secondary turns with their insulation occupied a space of abnormal proportions. The resistance of the primary was 1.65 ohms, and that of the secondary was 0.71 ohms.

The maximum magnetization used in the core in any of the experiments here described, was not above 3,000 lines per square cms.

The diagrams, Figs. 2, 4, 5 and 6, represent graphically the observations that were made with the apparatus.

From these diagrams are deduced the following results:

Fig. 2. Secondary open; no extraneous heat applied; temperature of the core, 97.5 C; primary E. M. F., 75.6 volts; secondary E. M. F., 16.4 volts; ratio $\frac{75.6}{16.4}$ 4.6; secondary current, 0.0.

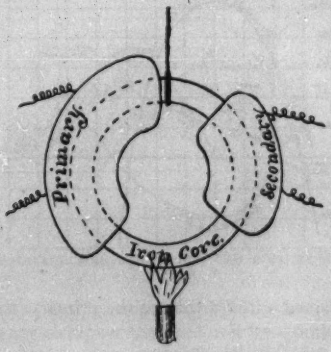


FIG. 1.

Fig. 4. Secondary open; core heated; temperature of core, 300 C; primary E. M. F., 99.4 volts; secondary E. M. F., 24.5 volts; ratio, $\frac{99.4}{24.5} = 4$; secondary current, 0.0.

Fig. 5. Secondary closed; no heat applied; temperature of the core, 100.0 C; primary E. M. F., 89.3 volts; secondary E. M. F., 11.9 volts; ratio, $\frac{89.3}{11.9} = 8.1$. secondary current, 2.0 amperes.

Fig. 6. Secondary closed; core heated; temperature of core, 270 C; primary E. M. F., 95.7 volts; secondary E. M. F., 13.4 volts; ratio, $\frac{95.7}{13.4} = 7.1$; secondary current, 2.4.

TABLE 1.

		Temp.	Primary E. M. F.	Primary Watts.	Second'y Watts.
2.	Secondary open, no heat applied to core.	97.5° C	75.6	87.	0.0
4.	Secondary open, heat applied to core ..	300.° C	99.4	88.	0.0
5.	Secondary closed, no heat applied to core.	100.° C	89.3	139.	24.
6.	Secondary closed, heat applied to core...	270.° C	95.7	129.	36.7

Data are presented in the latter part of this paper showing that it is correct to assume for small ranges that the loss in the core is proportional to the square of the primary E. M. F.

We can, therefore, deduce from Table 1 the results that would

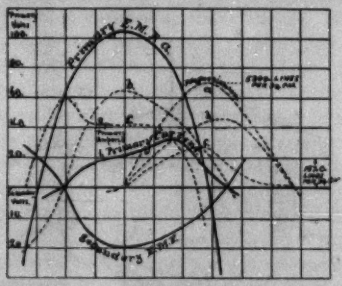


FIG. 2.

have been obtained with 90 volts as the primary E. M. F. for the four experiments.

TABLE 2.

	Temp.	Primary, 90 volts. 120 reversals per sec. Loss in core.	Primary Watts.	Secondary Watts.	
2.	97.5° C	122.	122.	0.0	
4.	300. ° C	73.	73.	0.0	
	270. ° C	79. (estimated)	79.	0.0	
5.	99. ° C	117.	131.	24.	corrected for resistance of secondary.
6.	270. ° C	80.	116.7.	36.7	

These figures in Table 2 show clearly that the loss in the core is greatly diminished when its temperature is elevated, *i. e.*, when heat is applied, and that the loss in the core is practically independent of the output. The results indicate that with the

secondary open and the primary at a difference of potential of 90 volts without heat applied, the core came to a temperature of 97° C., and dissipated 122 watts; then by the application of heat with the Bunsen burner, as indicated in Fig. 1, the temperature of the core was raised to 300° C, and was found to take up 72 watts. Now, if we assume the change in watts dissipated in the core to be approximately proportional to the changes in temperature that produced the same, then we see by estimation that 79 watts would have been dissipated by the core at 270° C, while 80 watts were found to have been dissipated by it at that temperature when the secondary was closed, and gave an output of 32 watts.

It is perfectly plain, therefore, why we can close the secondary, take from it 32 watts, elevate the temperature of the core 170° C, and have the primary take up 5 watts less than

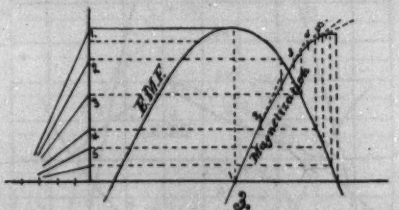


FIG. 3.

when the secondary was open, and the core at the lower temperature.

Since the effect is due only to the fact that the core takes much less energy at higher than at lower temperatures, and since the core can dissipate energy through Foucault current and hysteresis phenomena only, it is due to a decrease of the total energy dissipated through changes in the above phenomena.

A rise of temperature in the core will increase its specific resistance, and therefore diminish the energy dissipated by Foucault currents. For decided degrees of magnetization it is known that the permeability of iron increases when it undergoes a rise of temperature. It was thought probable, therefore, that the energy dissipated per cycle of magnetization and demagnetization would be decreased with an increase of temperature.

Experiments were made in the Physical Laboratory of Cornell University by Arthur Herschel on the hysteresis at high temperatures of a cast-iron ring, 12.3 cms. in diameter that furnished a closed magnetic circuit, the length of which is 38.5 cms. The ring was wound with 30 turns of No. 8 wire cable that had a mica insulation.

The highest temperature to which the ring was subjected was 360° C. The results of those experiments are represented graphically in Fig. 7.

One interesting thing about these results is that for degrees of

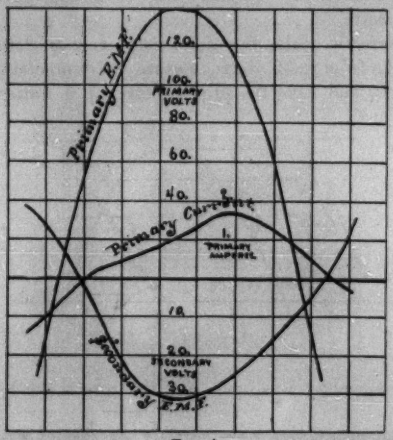


FIG. 4.

magnetization below 2,000 lines per square cm. the variation of temperature below 360° C. does not change the magnetic character of the iron by an observable amount. For if wrought iron behaves in a similar manner then the decrease of energy dissipated in the apparatus of Mr. Marks was not due wholly nor in part to a diminution in the hysteresis of the iron. It was therefore due entirely to the diminution in Foucault currents, caused by the change of the resistance of the iron. A liberal estimate for the hysteresis of the core is twenty watts, whence the Foucault energy dissipated by the core at 100° C and 90 volts was 102 watts, and at 270° C and 90 volts it was 60 watts.

The range of temperature that produced this change was 170°. The magnetization for each condition is the same, so that it is fair to assume that E. M. F. setting up the Foucault currents is the same, and that, therefore, the energy dissipated by Foucault currents will diminish as the resistance of the iron is increased by the elevation of its temperature.

This gives us a rough determination for the temperature coefficient of the iron to be .4 of one per cent. per degree centigrade, which agrees with Matthiessen's determination and furnishes a fair check upon the conclusion just arrived at.

The second interesting feature about the performance of Mr. Marks's apparatus lies in the fact that the ratio of primary to secondary turns was 3.2, while the relation of primary to secon-

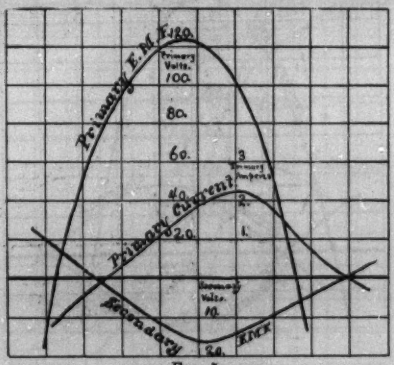


FIG. 5.

dary E. M. F.,s varied from 4 to 8. In this it exhibited exceedingly bad regulation so that by examination of the diagrams 2, 4, 5 and 6, we can see in exaggerated form the trouble it is so hard to become rid of in transformers to be used for incandescent lighting. Any one of these diagrams shows that a large portion of the lines of magnetization that were set up about the primary was not set up about the secondary. That is to say, the counter E. M. F. that is produced in the primary is due to the magnetization through it, that also took place through the secondary, plus the variation of magnetization that was set up in its own air space and that leaked by the secondary through the air. When

the transformer furnishes current this difference becomes greater and greater, because of the increased current in the primary and the setting up of a counter magnetization by the secondary current in its own air space that still further reduces the magnetization through it.

Fig. 1 shows the primary disposed on one side and the secondary on the other side of the annular core. The insulation was provided by thick asbestos paper that produced large air spaces between the turns in which magnetization was provided.

In Fig. 2, E. M. F., curve b, is the counter E. M. F. in the primary produced by the magnetization through it that also took place through the secondary and which is obtained by multiplying

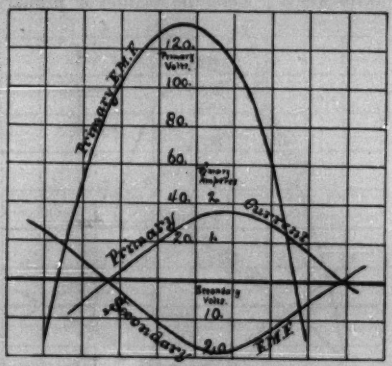


FIG. 6.

the secondary E. M. F. by 3.2, the ratio of the turns; E. M. F. C is the curve of counter E. M. F. in the primary that was produced by magnetization through the primary that did not take place through the secondary. This is obtained by subtracting E. M. F. b from E. M. F. a; E. M. F. c is seen to be approximately proportional to the rate of change of the primary current, which suggests magnetization that is set up through the primary that is proportional to the primary current. or that which is set up in the air, or in a magnetic circuit compounded of iron and air.

In the same figure the curves of magnetization a and b are obtained graphically from the curves of E. M. F. a and b by the method shown in Fig. 3.

This method is found to be fully as accurate and requires much less time and is more simplified than the analytic method, making use of Fourier's theorem. By substracting b from a we obtain c, the curve of magnetization that was produced through the primary and not through the secondary. This curve of magnetization, c, is seen by the diagram to be of about the same form as the current curve, but to lag behind the latter, which indicates that it was magnetization that was produced through air, and air and iron

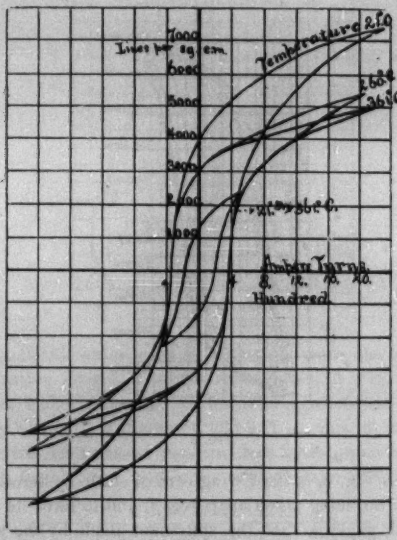


FIG. 7.

During the discussion at a recent meeting of the Institute the question was asked whether measurements of Foucault currents and hysteresis, as separated from each other, had ever been made.

There can be no doubt but that we do have separate determinations of those quantities when we have determined the energy dissipated in a magnetic circuit of iron by rapid cycles of magnetization and demagnetization, and the energy dissipated by

static hysteresis for the same rapidity and degree of magnetic changes as determined from a Ewing card, observed through slow magnetization and demagnetization.

Figs. 8 and 9 are two good illustrations of such determinations.

In Fig. 8, the outer card represents the card obtained from the existing current and magnetization curves taken carefully at 138 periods from the 10-light transformer upon which the tests were made that were communicated to the Institute by the writer at the last December meeting.[1] The inner card drawn in

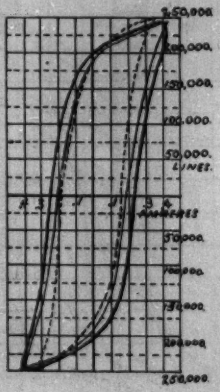


FIG. 8.

a full line in Fig. 8, is the Ewing card of static hysteresis. This transformer on being taken apart was found to have its discs insulated with paper so that the statement made by the writer in December in regard to the insulation of the transformer was erroneous in this particular. Foucault currents should therefore be found to be quite absent as the diagram in Fig. 8 indicates. A study of these cards does not reveal that which can be recognized as a trace of viscous hysteresis and they differ only by an amount of Foucault current energy that is represented by a small current lagging approximately an eighth of a period behind the primary impressed E. M. F.

1. TRANSACTIONS p. 1 *ante*.

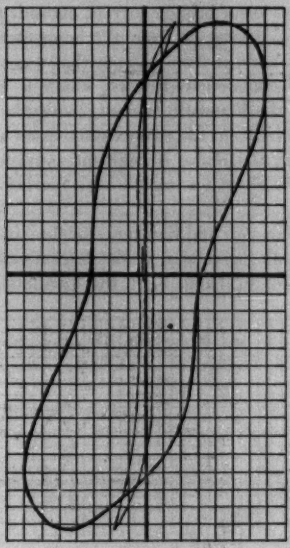


FIG. 9.

In Fig. 9. the outer card is deducted from the current and magnetization curves that are represented in Fig. 12. These curves were obtained with 195 alternations per second from a cast iron ring 8. 6 cms. in diameter, and 2. 7 sq. cms. in cross-section, wound with 200 turns of wire that had a negligible resistance.

In Fig. 9, the inner card is the card of static hystersis.

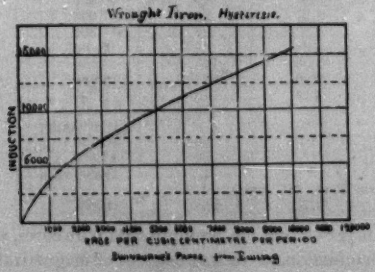


FIG. 10.

In Fig. 12, the lower broken current curve is that of the exciting current curve drawn in from the inner card of Fig. 9. By subtracting this current from the one that was observed, we obtain the upper broken current curve, which is the current that exists to supply the Foucault current energy in the core. The point to be noticed from the two extreme cases here taken up is that in each case the curve or current supplying the Foucault current energy is about one-eighth of a period behind the impressed E. M. F.

Messrs. Fortenbaugh and Sawyer, students in electrical engineering at Cornell University, made determinations, the results of which are given in Table 3, of the amounts of energy that

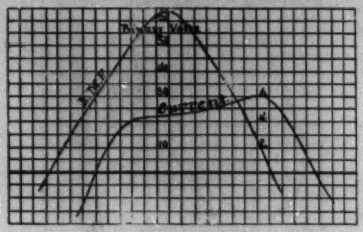


FIG. 11.

TABLE 3

Coil of wire B. & S. G.	Area of coil sq. cms.	Periodicity.	Magnetization per sq. cm.	Loss Watts per cu. cm.
1 12	5.	169	5,300	.18
2 12	5.	177	8,560	.46
3 12	5.	177	11,180	.75
4 16	4.9	173	6,000	.14
5 16	4.9	175	9,430	.33
6 16	4.9	167	10,930	.43
7 16	4.9	93	7,250	.10
8 16	4.9	92	13,360	.41
9 16	4.9	45	13,000	.10
10 24	3.56	175	8,150	.19
11 24	3.56	53	8,760	.12
12 36	3.14	173	9,200	.16
13 36	"	173	14,900	.29
14 36	"	173	18,000 app.	.48
15 36	"	96	10,700	.15
16 36	"	92	17,800	.33
17 36	"	47	18,000 app.	.13
(Cast iron diam., 8.6 cms.)				
18 36	2.7	160	4,920	1.50

are taken up per cu. cm. in wrought-iron wire cores, of different degrees of lamination, at various degrees of magnetization, and at

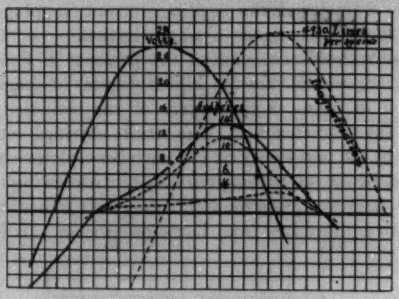


FIG. 12.

different periodicities in which the oxydized surface of the iron was depended upon for insulation. They made use of four iron wire rings the mean diameter of each of which was 8.9 cms. and on each of which were wound 200 turns of wire that had a negligible resistance.

Figs. 11. and 13, are given for illustrating the extreme varia

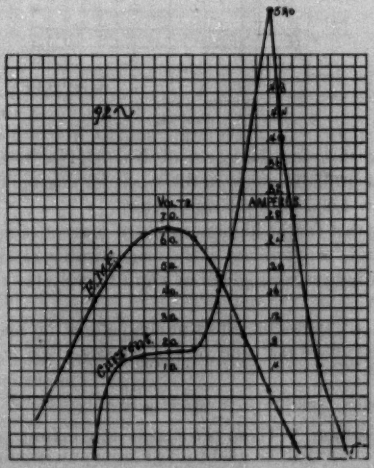


FIG. 13.

tion in the character of the exciting current in going from the lowest to the highest degree of magnetization.

The results show on account of the presence of Foucault currents to a larger extent for the higher degrees of magnetization, a variation in losses as the square of the periodicity and the square of the magnetization. The results obtained with the several cores at the periodicity of 175 have been plotted in Fig. 14.

The core of No. 36 wire agrees closely with Ewing's determination of static hysteresis for moderately soft wrought-iron, and is therefore entirely free from Foucault currents. It is interest-

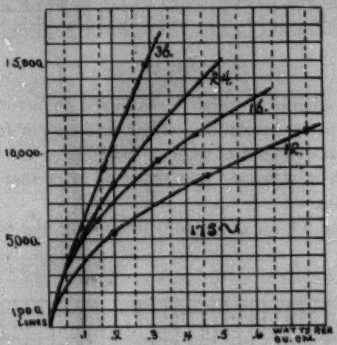


FIG. 14.

ing to note that for the cores of No. 36, No. 24 and No. 16, there is but little difference in the losses for degrees of magnetization below 4,000 lines per centimeter.

Likewise that for the higher degrees of magnetization it is seen that the loss is proportional to the magnetization as Ewing's results on static hysteresis given in Fig. 10 indicates they should be.

Diagram 13, shows the effect of compelling the magnetization to be carried above the bend of the characteristic curve of the iron.

DISCUSSION.

THE PRESIDENT:—These two papers are before you now for discussion. We shall be glad to hear from any members of the Institute or others who have anything to say upon the subject.

DR. GEYER:—I do not recollect Prof. Ryan stating how those

lines of which figure 14 gives a graphic representation were determined. I would ask him to please state that?

PROF. RYAN:—They were determined in the same manner that the loss is determined in the transformer that was described—that is, by observing the curves of current and E. M. F., and deducting Watt curves from them.

DR. GEYER:—You got simultaneous currents and electromotive force curves?

PROF. RYAN:—Yes, sir.

DR. GEYER:—And all these curves on the first half of the page were determined by the same general method?

PROF. RYAN:—Yes, sir.

Dr. GEYER:—Do I understand you to say that the curve of primary in fact would vary with every variation in the running of the machine?

PROF. RYAN;—Not in every variation of the running of the machine; but it was observed to vary when the field excitation of the machine was changed. The excitation was changed in order to get a change of E. M. F. I do not suppose its performance would be found to be just like a large machine.

DR. LOUIS BELL:—I would like to ask Mr. Powell about the iron in that transformer. I confess that I have a good deal of faith in iron good enough to give an all-round efficiency of 90 per cent. I would like to know how the thickness of the iron in that forty-light transformer compared with the thickness of the iron in the ten-light transformer; in other words, whether he determined in detail its magnetic properties aside from those given on this paper?

MR. POWELL:—We did not measure the thickness of the iron, but as far as I am able to judge, it was of the same thickness; and, in regard to that Ewing card, we took several, one after another, and they are all practically the same. That was as far as we went in studying the properties of the iron.

MR. TOWNSEND WOLCOTT:—In any of these curves of hysteresis did you obtain evidence of viscous hysteresis?

PROF. RYAN:—No, sir.

MR. WOLCOTT:—That result is very interesting and seems a little extraordinary to me.

PROF. RYAN:—What I mean by the matter is merely this; that the agreement of the card of static hysteresis is so close with that observed at the high rate of magnetic change that from that I was of the opinion that one could see very little effect due to viscous hysteresis, unless I have a wrong impression as to what viscous hysteresis is.

MR. WM. STANLEY, JR.:—Professor Ryan has spoken of the constant polarix. If you look at Humphrey and Powell's paper, on the left hand side near figure 2 there is a section of the converter. A smaller coil represents the secondary, and the larger coil the primary. That same action described by Prof. Ryan

takes place in this converter. The secondary heads off the lines from the primary from passing through the secondary circuit. This causes a drop of potential in the converter between open circuit and a full load of about two volts over that which is found by the wasting of energy in the converter. I would like to ask Prof. Ryan what was the maximum number of lines per square centimetre that he used in the magnetization curves of the forty-light transformer?

PROF. RYAN:—I do not know that I can answer that question exactly, but I am very sure that the maximum number that Messrs. Powell and Humphrey used in their experiments was not higher than about forty-five hundred lines per square centimetre. The diagram that is presented here is incorrect, Mr. Stanley, and the figures given there should be multiplied by about four-tenths and the proper values would then be attained.

MR. STANLEY:—I think it is the general practice to use about 3,000 for magnetization.

MR. JOSEPH WETZLER:—I did not quite catch what Prof. Ryan described as the difference in the ratio of electro-motive force in the primary and the secondary in his experiments.

PROF. RYAN:—To what the difference is due?

MR. WETZLER:—Yes, sir; to what it would describe.

PROF. RYAN:—(Indicating a figure on the blackboard). There is a great deal of air space surrounding the wires of the primary and those of the secondary, and while the magnetic resistance of air is very much higher than that of iron, that of the air circuit is very short and a certain amount of magnetization is set up about the wires of the primary in its own air space. On account of the Foucault currents that are set up on this side a certain number of lines will often pass down between the primary and the secondary coils, and since the secondary does not embrace all of the lines of force therefore, that are set up in the primary, the electro-motive force that is produced in the secondary will not be that which the ratio of the terms of the primary to the terms of the secondary would indicate. That is, if we had taken the 155 turns and had wound them right in here in the same position that the turns of the primary were wound, then we should have obtained a ratio of transformation that is exactly equal to that of the ratio of the turns.

MR. STANLEY.—Isn't it possible that the air space increases the lag of the secondary current? Three or four years ago I made a transformer that would give a constant current on the secondary by making the same device that Prof. Ryan has shown and bringing the center web down. Prof. Thomson also did something of the kind But if the secondary coil has a local magnetic circuit wherever it is so placed upon the core that the air resistance around the secondary current is low, then it changed the lag of the secondary current and you get a constant secondary current constantly applied to the primary potential.

PROF. RYAN.—We have observed just that very thing in making our experiments with transformers also.

MR. WETZLER.—Mr. Stanley has remarked that in order to overcome the leak that occurs when the wires are wound side by side they have been super-posed. I would like to know what the effect of that increased length of wire would be which would be required in such a case?

MR. STANLEY.—If one were wound on top of the other, the secondary would be proportionately shorter and the primary proportionately longer.

PROF. RYAN:—I would like to say a word further in regard to the point referred to by Mr. Stanley, and that is the large amount that the secondary electromotive force fell off in these experiments of Mr. Marks, which shows the point quite well, I think, that Mr. Stanley has brought up. That is, when you allow the secondary to furnish current, then lines of force are set up in the air space of the secondary, counter to the lines of force that are already set up through the core, and since they are in opposite directions, what you get so far as electromotive force is concerned in the secondary is virtually the sum of the two, and that therefore when you load down the secondary, the secondary difference of potential will go right on down and have no relations hardly to the internal resistance of the apparatus.

MR. STANLEY:—Has Prof. Ryan ever considered the problem of transforming alternate currents by using high periods, possibly 10,000 a second, and no iron? I think that is a very good field for investigation.

PROF. RYAN:—We have never attempted anything in that line, I think, though, it is a very interesting field.

A MEMBER:—I notice in some of these curves of magnetization, as they are called, that they seem to be followed by the sine law, and I did not catch very clearly how they were obtained, whether by experiments or not. But if we plot out from the hysteresis curves of Ewing's curves of magnetization resulting from a magnetization current which follows the sine law, the magnetism resulting from that will not by any means follow the sine law. It will be a rather blunt curve, coming up sharply at the start, and then remaining near the maximum value for quite a length of time. That is, it will be flat on top. I would ask Prof. Ryan if any such result has been obtained in any of his researches or experiments, or how this curve was obtained that he has here?

PROF. RYAN:—In answer to the one question I would say that we have taken what is usually called a "choke coil," and, as it were, forced an alternating current of a sine curve through it and obtained such a difference of potential as would indicate the curve of magnetization; then, when you work back by means of this curve of electromotive force, which is equal to the change of magnetization, it shows just such a curve of magnetization as

you say you get by the card of static hysteresis of Ewing. And with regard to the manner in which these curves of magnetization here have been obtained, I would say that in some cases they have been obtained analytically by determining an equation compounded of sine curves that express the curve of electromotive force that was actually obtained, and from that, determining the curve of magnetization, which curve of magnetization is merely a curve whose rate of change of ordinates is proportional to the curve of the electromotive force that was actually observed. You have a different case in a transformer where the resistance of the primary is practically ineligible as compared to the full pressure on the primary. There, the magnetization must follow the law which is defined as the rate of change in the curve of primary electromotive force. It has to do that, regardless of what current must flow to produce such magnetization in the circuit of the transformer. And that is quite well brought out in one of the diagrams which I have here. (Here the Professor illustrated from a diagram on the blackboard). We have here a coil sometimes called a "choke-coil," but merely a magnetic circuit wound with a certain number of turns of wire that had quite entirely a negligible resistance, and it was subject to a certain difference of potential, and if the resistance of the coil be negligible, then current will flow at any instant to make the rate of change in magnetization in that magnetic circuit proportional to the difference of potential to which it is subjected. The consequences were that at this point (indicating) this coil of No. 36 iron wire came to a magnetization of about 15,000, and it took a considerable number of ampere turns to raise its magnetization beyond that. In some cases I know that it went very much higher than that, in making the magnetization follow a sine curve throughout that side (indicating).

A MEMBER:—I would like to learn if Professor Ryan knows about what temperature the increase of economy disappears by heating the core on account of the magnetic property of the iron?

PROF. RYAN:—I think that is a matter that is entirely known. You see since this effect can only come in, when you have a large quantity of energy dissipated by Foucault currents, that in the case of commercial transformers there would be no such limit. Mr. Herschel's results show, too, within the ranges of magnetization that would be used in a commercial transformer that any temperature to which it would be subject would not change the hysteresis by an observable amount, and therefore I think that so far as a practical view is concerned, such limit would not be sought.

MR. CHARLES STEINMETZ:—Professor Ryan says they could find the magnetization of the core by calculating an analytical expression given by the scope of electromotive force. I would ask whether he found in this analytical expression of the primary

electromotive force special peculiarities. For instance, that the second curve of hysteresis has a special check?

PROF. RYAN:—I remember last summer of our having taken some curves and drawn them out on cross-section paper—that is, the various orders and the higher orders—and I do not remember any peculiarities. We drew then out as sine curves, and when we added them up we got the real curve of electro-motive force. There is a matter that I should like to speak of, and that is that when a curve of electromotive force is flat at the top, of course the magnetizing current curve is just so much sharper. And the contrary, I suppose would also be true. I would like also to say a word for the benefit of those that have probably not seen Dr Somner's paper, that I think appeared in the proceedings of the Royal Society about two years ago. A method is there given by him, by means of which—when you have a complicated case of the primary and the secondary, or merely a primary. or rather, a wire circuit in the presence of a magnetic circuit alone, but which wire has considerable resistance, and therefore in which case the fall of potential does amount to considerable, the problem treated analytically being a very difficult one—you can determine what would happen beforehand. By the method that is there presented the entire matter can be worked out graphically without much trouble. I can give you an idea of what the elemental curves look like, to give a resulting curve that is the same as one that can be produced by one of the ordinary alternators used in this country, in which the drum type of armature is used. (Illustrating by a drawing on the black-board). When you plot in the sine curve of the first order it is always steeper. The second order drops out. Then the next is three, something like that. (Indicating). The fourth, of course, drops out. Then we have five alternations running along, two and a half on this side and two and a half on the other. (Indicating). That is the only analysis of the curve that we have made.

THE PRESIDENT:—I notice that in Mr. Powell's paper he speaks of obtaining the mean current in a number of cases, as the square root of the mean square of the instantaneous currents throughout the curve. I should like to know if he has made any investigation of the application of that method to such irregular curves as are shown here in a number of cases, where the curve is nothing like a sine curve.

MR. POWELL:—The only cases in which we use the square of the mean square, were in cases of the secondary electromotive force and secondary current. The resistance being known, the secondary current would be a function of the secondary electromotive force. We did not have any method of determining the values of the secondary current except in that manner. We measured the secondary current by an electro dynamometer, and assumed that that was the mean square, as this curve is very

nearly the sine curve (indicating). In all cases in the primary circuit we determined the watt curves, as shown in plate 7, and then found the mean watt ordinate.

PROF. RYAN:—An interesting case for such a comparison would have been Fig. 13, but I am sorry to report that we did not make such comparison in the observation. In some work that we did last summer we always found with the instruments, that they compared within one or two per cent. with the square root of the mean square determined from the diagram.

Adjourned.

American Institute of Electrical Engineers

LIST OF MEMBERS.

November 1st, 1890.

HONORARY MEMBERS.

Name	Address.	Date of Membership.
Preece, Wm. H. *F. R. S.*	Electrician, General Post Office, London, Eng. Residence, Gothic Lodge, Wimbledon	Oct. 21, 1884
Farmer, Prof. Moses G.	Electrician and Inventor, Eliot, Me.	A April 15, 1884 H.M. Oct. 21, '90
Green, Dr. Norvin	(*Past President*). Pres't Western Union Telegraph Co. P. O. Box 3393, 195 Broadway, New York.	A April 15, 1884 M Oct. 21, 1884 H.M. Dec. 3, 1889

MEMBERS.

Acheson, Edw. G.	Electrician, Monongahela City, Pa.	A Jan. 3, 1888 M May 1, 1888
Ahearn, T.	Ahearn & Soper, Electrical Supplies, Ottawa, Ont.	A July 12, 1887 M Sept. 6, 1887
Anthony, Prof. W. A.	Consult'g Electrician. The Mather Electric Co., Manchester, Conn	A Dec. 9, 1884 M Jan. 6, 1885
Batcheller, B. C.	Superintendent of the Pneumatic Dynamite Gun Co., 71 Broadway, New York.	A Sept. 6, 1887 M Nov. 1, 1887
Batchelor, Chas.	Electrical Engineer, 33 West Twenty-fifth St., New York.	A June 8, 1887 M July 12, 1887
Bates, J. H.	Box 2702, New York.	A Sept. 6, 1887 M Oct. 1, 1889
Bates, Maurice E.	Manager, Western Electric Construction Co., 503 Delaware St., Kansas City, Mo.	A Aug. 6, 1889 M Oct. 1, 1889
Bayly, B.	Surveyor and District Engineer, Western District Colonial Gov't. Cape Town, Cape of Good Hope, Africa.	A Oct. 4, 1887 M Dec. 6, 1887
Bell, Prof. A. Graham	1336 Nineteenth St., Washington, D. C.	A April 15, 1884 M Oct. 21, 1884
Bell, Dr. Louis,	Editor *Electrical World*, 167 Times Building, P.O. Box 3332, N. Y.	A May 20, 1890 M June 17, 1890
Bernard, Edgar G.	Electrical Engineer, Genesee House, Utica, N. Y.	A Jan. 5, 1886 M July 12, 1887
Birdsall, E. T. *M. E.*	Electrical Engineer, 115 Broadway, New York.	A June 8, 1887 M Nov. 1, 1887

Name.	Address,	Date of Membership.
BLAKE, EDWARD	Treasurer of New England Electric Co., 55 Oliver St., Boston, Mass.	A May 24, 1887 M Sept. 3, 1889
BLAKE, FRANCIS	Auburndale, Mass.	A Sept. 3, 1889 M Oct. 1, 1889
BLODGETT, GEO. W.	Electrical Engineer B. & A. R. R. and Consulting Electrician, Boston, Mass.	A July 12, 1887 M Sept. 6, 1887
BOSCH, ADAM	Sup't, Fire Alarm Telegraph, Newark, N. J.	A April 15, 1884 M Jan. 6, 1885
BRADLEY, CHAS. S.	Electrical Engineer, Yonkers, N. Y.	A May 24, 1887 M Dec. 6, 1887
BROOKS, MORGAN	Secretary and Treasurer, The Electrical Engineering & Supply Co., 413 Jackson St., and 529 Holly Ave., St. Paul, Minn.	A May 20, 1890 M June 17, 1890
BROWN, JO. STANFORD	Electrical Engineer, with United Electric Traction Co. 115 Broadway, New York.	A Sept. 6, 1887 M Nov. 1, 1887
BRUSH, CHAS. F.	Electrical Engineer, 956 Euclid Ave, Cleveland, O.	A April 15, 1884 M Oct. 21, 1884
BYLLESBY, HENRY M.	Vice-President and Gen'l Manager, Westinghouse Electric Co., Pittsburgh, Pa.	A Sept. 7, 1888 M Oct. 2, 1888
CARROLL, LEIGH	President and General Manager, The Edison Electric Illuminating Co., Birmingham, Ala	A Oct. 1, 1889 M Nov. 12, 1889
CHAMBERLAIN, J. C.	(*Manager.*) Supt. Julien Electric Traction Co , 135 East 18th St., New York.	A Dec. 6, 1887 M Jan. 3, 1888
CHEEVER, CHAS. A.	13 Park Row, New York.	A April 15, 1884 M Oct. 21, 1884
CHURCH, WM. LEE	Member of Westinghouse, Church, Kerr & Co., Engineers, 620 Atlantic Ave., Boston, Mass.	A April 5, 1887 M May 17, 1887
CLARK, ERNEST P.	Electrical Engineer, 192 Broadway, New York.	A Jan. 8, 1887 M Nov. 1, 1887
CLARKE, CHAS. L.	Mechanical and Electrical Engineer, 55 Liberty St., New York.	A April 15, 1884 M Jan. 6, 1885
COLBY, EDWARD A.	Electrician of the Weston Electrical Instrument Co., 606 High St., Newark, N. J.	A April 2, 1889 M May 7, 1889
CONANT, THOMAS P.	District Engineer, Edison General Electric Co., Edison Building, Broad St., Box 3067, New York.	A Nov. 1, 1887 M Jan. 3, 1888
CONDICT, G. HERBERT	General Manager, The Electric Car Co. of America, 4720 Green St., Germantown, Pa.	A July 12, 1887 M Sept. 6, 1887
COTHREN, WM. H.	Sup't of Wiring Department, Edison Electric Illuminating Co., 432 Fifth Ave., New York.	A Aug. 6, 1889 M Oct. 1, 1889
COWLES, ALFRED H.	Technical Adviser to the Cowles Smelting and Aluminum Co., Lockport, N. Y.	A Mar. 5, 1889 M May 7, 1889
CROCKER, FRANCIS B.	(*Vice-President.*) Instructor in Electrical Engineering, School of Mines Columbia College, and 54 W. 21st Street, New York.	A May 24, 1887 M April 2, 1889

Name.	Address.	Date of Membership.
CROSS, PROF. CHAS. R.	Thayer Professor of Physics, and Director of the Rogers Laboratory. Mass. Institute of Technology, Boston, Mass.	A April 15, 1884 M Oct. 21, 1884
CUTTRISS, CHAS.	(*Manager*). Electrician. The Commercial Cable Co., 1 Broad St., New York.	A Nov. 1, 1887 M Dec. 6, 1887
DAFT, LEO	Electrician, Plainfield, N. J.	A Dec. 9, 1884 M Jan. 6, 1885
DANVERS, ALAN	Managing Director and Chief Electrician, The Anglo-Portugese Telephone Co., L't'd. 60 Travessa Santa Justa, Lisbon, Port'l.	A Nov. 1, 1887 M Sept. 3, 1889
DANVERS, ERNESTO	Electrical Engineer, Casilla 74, Rosario, Argentine Republic.	A Jan. 3, 1888 M May 1, 1888
DAVIES, JOHN E	Professor of Physics, University of Wisconsin, 523 Carroll St. Madison, Wis	A Jan. 7, 1890 M Mar. 18, 1890
DAVIS, CHARLES H.	Consulting Electrical Engineer, 120 Broadway, New York.	A Mar. 18, 1890 M June 17, 1890
DELAFIELD, A. FLOYD, *Ph.D.*	Electrical Engineer, Noroton, Conn.	A May 7, 1889 M Oct. 1, 1889
DICKENSON, SAMUEL S.	Sup't, Commercial Cable Co., Hazel-Hill, Guysborough Co., N.S.	A Mar. 6, 1888 M Oct. 1, 1889
DIEHL, PHILIP	Inventor. Singer Sewing Machine Co., Elizabeth, N. J.	A April 15, 1884 M Dec. 9, 1884
D'INFREVILLE, GEORGES	Electrical Engineer and Expert 110 Liberty St., New York.	A Nov. 1, 1887 M Dec. 6, 1887
DOIJER, H.	Care of J. G. F. Rooker, W. I. Vostringel. Delft, Holland.	A Jan. 7, 1890 M Mar. 18, 1890
DUDLEY, CHARLES B.	Chemist and Scientific Expert, Penn. R. R. Co., 1219 Twelfth Ave., Altoona Pa.	A Oct. 1, 1889 M Nov. 12, 1889
DUNCAN, DR. LOUIS	(*Vice-President*). Johns Hopkins University, Baltimore, Md.	A July 12, 1887 M Sept. 6, 1887
DYER, R. N.	Patent Attorney, 40 Wall St., New York.	A July 12, 1887 M Sept. 6, 1887
EDISON, THOMAS A.	Electrician and Inventor, Orange, N. J.	A April 15, 1884 M Oct. 21, 1884
FARNHAM, ISAIAH H.	Electrician for the N. E. Telephone & Telegraph Co., 50 Pearl St., Boston, Mass.	A June 8, 1887 M July 12, 1887
FIELD, C. J.	President and General Manager Field Engineering Co., 15 Cortlandt St., New York.	A June 8, 1887 M Nov. 1, 1887
FIELD, STEPHEN D.	Electrician and Inventor, Stockbridge. Mass.	A April 15, 1884 M Oct. 21. 1884
FITCH, D. H.	President, The Fitch Battery and Electric Co., Oneida, N. Y.	A Sept. 3, 1889 M Oct. 1, 1889
FLEMING, WILFRID H.	Care of Howard Fleming, Park Ave., Plainfield, N. J.	A Dec. 6, 1887 M Jan. 3, 1888
FOSTER, HORATIO A.	(*Manager.*) Electrical Engineer, 45 E. Twenty-second St., New York.	A June 8, 1887 M Sept. 6, 1887
FREEMAN, DR. FRANK L.	Attorney-at-Law, Solicitor of Patents, Electrical Expert. 931 F St., Washington, D. C.	A May 7, 1889 M Sept. 3, 1889

Name.	Address.	Date of Membership.
GARRATT, ALLAN V.	Care Electric Club, 17 East 22d Street, New York.	A April 2, 1884 M May 7, 1889
GARVER, M. M.	48 Walnut St., Newark, N. J.	A July 10, 1888 M Sept. 3, 1889
GEYER, DR. WM. E.	(*Manager*). Stevens Institute of Technology, Hoboken, N. J.	A June 5, 1888 M Sept. 7, 1888
GRISCOM, WM. W.	Haverford College P. O., Montgomery Co., Pa President, The Electro Dynamic Co., 224 Carter St., Philadelphia and Managing Electrician The Electrical Accumulator Co., New York.	A June 5, 1888 M Mar. 18, 1890
HALL, CLAYTON C.	Civil Engineer, 810 Park Ave., Baltimore, Md.	A April 15, 1884 M Oct. 21, 1884
HAMBLET, JAMES	Manager Time Service, W. U. Tel. Co., 195 Broadway, P. O. Box 3393, New York.	A Nov. 1, 1887 M Dec. 6, 1887
HAMILTON, GEO. A.	Electrician, Western Electric Co., 22 Thames cor. Greenwich St., New York.	A April 15, 1884 M Oct. 21, 1884
HAMMER, W. J.	Consulting and Supervising Electrical Engineer, 533 Temple Court, N. Y., and 23 Rowland St., Newark, N. J.	A June 8, 1887 M July 12, 1887
HANCOCK, WM. J.	Supt. of Telephones, Dept. of Public Works, Perth, Western Australia.	A Jan. 7, 1890 M Mar. 18, 1890
† HASKINS, CHARLES H.	Electrician, care of New York Club, Fifth Ave. and Thirty-fifth St., New York.	A April 15, 1884 M Oct. 21, 1884
HAYES, HAMMOND V.	Electrician, American Bell Telephone Co., Boston, Mass. 127 Purchase St., Cambridge, Mass.	A Nov. 12, 1889 M Mar. 18, 1890
HAYNES, F. T. J.	Divisional Telegraph Engineer, Great Western Railway, Taunton, Eng.	A Dec. 6, 1888 M Jan. 3, 1887
HAZARD, COL. ROWLAND R.	N. Y. District Railway Co., 120 Broadway, New York.	A April 15, 1884 M Oct. 21, 1884
HERING, CARL	Consulting Electrical Engineer, 3816 Spring Garden St., Philadelphia, Pa	A Jan. 3, 1888 M June 5, 1888
HERZOG, DR. F. BENEDICT	(*Manager*) President Herzog Teleseme Co., 30 Broad St., New York.	A May 24, 1887 M July 12, 1887
HIGGINS, EDWARD E.	Electrical Engineer, Edison Building, Broad Street, New York. P. O Box 3067, New York City.	A June 8, 1887 M July 12, 1887
HOUSTON, PROF. EDWIN J.	1521 Mt. Vernon St., Philadelphia, Pa.	A April 15, 1884 M Oct. 21, 1884
HOWELL, JOHN W.	Electrician, Edison Lamp Co., Harrison N. J.	A July 12, 1887 M June 5, 1888
HOWELL, WILSON S.	Electrical Expert. Central Station, Edison Elec. Light Sysem, New Brunswick, N. J.	A Sept. 3, 1889 M Mar. 18, 1890
HUNTER, RUDOLPH M.	Mechanical and Elect'al Engineer, 926 Walnut St., Philadelphia, Pa	A July 13, 1886 M May 17, 1887
HYDE, JEROME W.	Springfield, Mass.	A June 8, 1887 M Nov. 1, 1887
JACKSON, DUGALD C.	District Engineer, Edison General Electric Co., Rialto Building, Chicago, Ill.	A May 3, 1887 M June 17, 1890

Name.	Address.	Date of Membership.
JACKSON, FRANCIS E.	With Edison Lamp Co, Harrison, N. J.	A Jan. 3, 1888 M June 17, 1890
JANNUS, FRANKLAND	Solicitor of Patents, 928-30 F. St Washington. D C.	A Nov. 12, 1889 M Mar. 18, 1890
JENKS, W. J.	Technical Department, Edison, General Electric Co., 44 Wall Street, New York.	A June 8, 1887 M Nov. 1, 1887
JOHNSON, E. H.	President, Interior Conduit and Insulation Co., 16 Broad St., New York.	A Feb. 7, 1888 M May 1, 1888
JONES, FRANCIS W.	Assistant Gen'l-Manager and Electrician, Postal-Telegraph Cable Co., 5 Dey St., New York.	A April 15, 1884 M Oct. 21, 1884
KNOWLES, E. R.	Civil, Electrical, and Mechanical Engieeer, 181 Broadway, N. Y. and 4390 Waverly Ave., Brooklyn, N. Y.	A June 8, 1887 M July 12, 1887
KNUDSON, A. A.	Electrican, 39 Nassau St., New York.	A Dec. 6, 1887 M Jan. 3, 1888
LANGE, PHILIP A.	Superintendent of Detail Department, Westinghouse Electric Co., Pittsburgh, Pa.	A Mar. 6, 1888 M June 5, 1888
LANGTON, JOHN	General Manager, Canadian Edison M'f'g Co, Sherbrooke, P. Q.	A Mar. 6, 1888 M June 5, 1888
LATTIG, J. W.	Sup't Telegraph, Lehigh Valley R. R., South Bethlehem, Pa	A June 8, 1887 M July 12, 1887
LAWSON, A. J.	Electrical Engineer and Contractor, Montreal, P. Q, Box 1009	A Mar. 18, 1890 M June 17, 1890
LEONARD, H. WARD	(*Manager*). General Manager, Edison General Electric Co, P. O. Box 3067, New York.	A July 12, 1887 M Sept. 6, 1887
LEONARD. M. B.	Electrical Engineer, and Supt. of Telegraph, Chesapeake & Ohio R'y. Co, Richmond, Va.	A Nov. 6, 1886 M May 1, 1888
LIEB, JOHN W, JR.	Chief Engineer, Societá Generale Italiana di Elettricita (Sistema Edison). Via S Radigonda N. 4, Milan, Italy.	A Sept. 6, 1887 M Nov. 1, 1887
LOCKWOOD, THOMAS D.	(*Manager*). Electrical Engineer. and Advisory Electrician. P. O., Drawer 2. Boston, Mass.	A April 15, 1884 M Oct. 21, 1884
LYNE, LEWIS F.	Mechanical and Elect'al Engineer, 307 Grove St., Jersey City, N. J.	A Jan. 3, 1888 M June 5, 1888
MAILLOUX, C. O.	Consulting Electrical Engineer, 32 Liberty St., New York.	A April 15, 1884 M Oct. 21, 1884
MARKS, WILLIAM DENNIS,	*Ph. B., C. E.* Edison Electric Light Co., Philadelphia, Pa.	A Feb. 7, 1888 M May 1, 1888
MARSHALL, J. T.	Inspector of Lamp Manufacture, Edison Lamp Co., Harrison, N. J.	A Oct. 1, 1889 M Nov. 12, 1889
MAYNARD, GEO. C.	Electrical Engineer, 1409 New York Ave., Washington, D. C.	A April 15, 1884 M Dec. 9. 1888
MILLIS, JOHN	Lieutenant of Engineers, U. S. Army. P.O. Drawer 432. New Orleans, La.	A July 7, 1884 M Mar. 3, 1885
MILLS, FRANK P.	Superintendent Cleveland Iron Mining Co., Ishpeming, Mich.	A Jan. 6, 1885 M Mar. 3, 1885

Name.	Address.	Date of Membership.
NICHOLS, EDWARD L.	(*Vice-President*). Professor of Physics at Cornell University. Ithaca, N. Y	A Oct. 4, 1887 M Dec. 6, 1887
PAINE, SIDNEY B.	Electrical Constructor, member of firm "Paine & Francis," 38 Pearl St , Boston, Mass.	A June 8, 1887 M Nov. 1, 1887
PARKS, C WELLMAN	Electrician, 1825 Fifth Ave., Troy, N. Y	A July 12, 1887 M May 1, 1888
PARSHALL, H. F.	Electrician, 7 N. Calvert Street, Baltimore, Md.	A Sept. 7, 1888 M Mar. 18, 1890
PATTEN, F. JARVIS	Electrical Engineer, 47 Barclay St., Residence, 10 West Thirtieth St , New York.	A Sept. 6, 1887 M Nov. 1, 1888
PFANNKUCHE, GUSTAV	Engineer and Inventor, Cleveland, O.	A Feb 7, 1888 M May 1, 1888
PICKERNELL, F. A.	Sup't. of Equipment, Amer. Tel. & Tel. Co., 18 Cortlandt St. N. Y.	A Feb. 7, 1890 M Mar. 18, 1890
POPE, FRANKLIN L.	(*Past President*). Consulting Electrical Engineer and Expert, 15 Wall St., N. Y. Residence, Elizabeth, N. J.	A April 15, 1884 M Oct. 21, 1884
PORTER, J. F.	403 N. 8th Street, St. Louis, Mo.	A Sept. 6, 1887 M Nov. 1, 1887
PRATT, J. HOWARD, JR.	Professor of Physics, Milwaukee Acad., Milwaukee, Wis.	A June 5, 1888 M Sept. 7, 1888
PRATT, ROBERT J.	Electrician. Manager, Electric M'f'g Co., Troy, N. Y.	A July 12, 1887 M Sept. 6, 1887
PRESCOTT, GEO. B., JR	(*Manager*). Electrical Engineer, General Agent, Day's Kerite Wire and Cables. 16 Dey Street. New York.	A July 12, 1887 M Nov. 1, 1887
RAYMOND, CHAS. W.	Civil and Electrical Engineer, Merrimac Consolidated Mining Co., Platoro, Conejos Co., Col.	A June 8, 1887 M May 17, 1887
RECKENZAUN, ANTHONY	Electrical Engineer, 7 Albert Terrace, Hemberton Road, Stockwell, London, S. W. England.	A Nov. 1, 1887 M Dec. 6, 1887
RECKENZAUN, FREDERICK,	Electrician, Box 225, West Hoboken, N. J.	A Mar. 6, 1888 M June 5, 1888
RICE, E. WILBUR, JR.	General Superintendent and Consulting Electrician, Thomson-Houston Elec. Co., Lynn, Mass	A Dec. 6, 1887 M Jan. 3, 1888
RIES. ELIAS E.	Electrician and Electrical Engineer, 430 South Broadway, Baltimore, Md.	A July 12, 1887 M Sept. 6, 1887
ROBERTS, E. P.	Electrician and Sup't, Swan Lamp Co., Belden St., Cleveland, O.	A Jan. 6, 1885 M Feb. 3, 1885
ROHRER, ALBERT L.	Electrical Engineer, with Thomson-Houston Electric Co., Lynn, Mass.	A Nov. 1, 1887 M May 1, 1888
SALOMONS, *Sir* DAVID LIONEL, *Bart. M. A.*.	Engineer and Barrister, Broomhill, Tunbridge Wells, Kent and 49 Grosvenor St., London, W., England.	A Feb. 7, 1888 M May 1, 1888
SCHLESINGER, WM. M.	Electrician of Schlesinger, Kimball & Co , Manufacturers of Electric Mining Machinery, 228 West Broad St., Columbus, O.	A Nov. 1, 1887 M Dec. 6, 1887

Name.	Address.	Date of Membership.
SCHULZE-BERGE, FRANZ	Edison Laboratory, Orange, N. J.	A Nov. 12, 1889 M Mar. 18, 1890
SHALLENBERGER, O. B.	Electrician, Westinghouse Electric Co., Pittsburgh, Pa.	A Sept. 7, 1888 M Dec. 4, 1888
SHEPARD, WM. E.	Electrician, The Cincinnati Inclined Plane Railway Co., Cincinnati, O.	A Feb. 7, 1890 M Mar. 18, 1890
SLATER, HENRY B.	Electrical Engineer and Electro Metallurgist, 1804 California Street, Denver.	A April 15, 1884 M Dec. 9, 1884
SMITH, HERBERT G. *	General Electrician, Quezaltenango, Guatémala.	A Mar. 6, 1888 M June 5, 1888
STANDFORD, WILLIAM *	Ass't Sup't Telegraphs, Colonial Gov't, Cape Town, Cape of Good Hope, Africa.	A Oct. 4, 1887 M Dec. 6, 1887
STEBBINS, THEODORE	Electric Railway Inspector, Thomson-Houston Elec. Co, 620 Atlantic Ave., Boston, Mass.	A July 9, 1889 M June 17, 1890
STIERINGER, LUTHER	Electrical Expert, 44 Wall St., Room 71, New York.	A June 8, 1887 M Nov, 1, 1887
TERRY, CHARLES A.	Lawyer, Westinghouse Electric Co, Pittsburgh, Pa.	A April 5, 1887 M May 17, 1887
THOMPSON, EDWARD P.	Consulting Electrician and Patent Attorney in Electrical Cases, 5 Beekman St., New York.	A April 15, 1884 M Dec. 3, 1889
THURNAUER, ERNST	Chief Engineer, Thomson-Houston International Elec. Co., Michaelisbrücke, 1, Hamburg, Germany	A Oct. 14, 1887 M Dec. 6, 1887
TROWBRIDGE, PROF. W. P.	School of Mines, Columbia College. New York.	A April 15, 1884 M Oct. 21, 1884
TURNER, WILLIAM S.	Electrical Engineer, Woodbridge & Turner, 74 Cortlandt St., New York.	A Dec. 7, 1886 M Oct. 2, 1888
VAIL, J. H.	Ass't Engineer in Chief, Edison General Electric Co., Edison Building, P. O. Box 3067, N. Y.	A June 8 1887 M Nov. 1, 1887
VAN DEPOELE, CHARLES J.	Electrician, Electrical Railway Department, Thomson-Houston Electric Co., Lynn, Mass.	A June 5, 1888 M Sept. 7, 1888
VANSIZE, WILLIAM B	Solicitor of Patents, 44 Broadway, New York.	A April 15, 1884 M Oct. 21, 1884
WADDELL, MONTGOMERY	Engineer, 18 Columbia Heights, Brooklyn, N Y.	A Feb. 7, 1888 M May 1, 1888
WALKER, SYDNEY F.	Electrical Engineer, 195 Severn Road, Cardiff, England.	A June 2. 1885 M May 17, 1887
WALDO, DR. LEONARD *	Electrical Engineer, The Aluminum Brass & Bronze Co., Bridgeport, Conn.	A June 5, 1888 M Dec. 4, 1888
WEAVER, W. D.	U. S. N., 144 Henry St. Brooklyn, N. Y.	A May 17, 1887 M May 17, 1887
WEEKS, EDWIN R.	General Manager, Kansas City Electric Light Co, National Bank of Kansas City Building. Kansas City, Mo.	A Sept. 6, 1887 M Nov. 1, 1887
WESTON, EDWARD	(*Past President* and *Vice-President*) Electrician, 645 High St., Newark, N. J.	A April 15, 1884 M Oct. 21, 1884

Name.	Address.	Date of Election.
WETZLER, JOSEPH	(*Vice-President.*) Editor *Electrical Engineer*, 150 Broadway, N. Y.	A April 15, 1884 M Dec. 9, 1884
WHARTON, CHAS. J.	82 Bond St., London England.	A Jan. 3, 1888 M May 1, 1888
WHEELER, SCHUYLER S., *Sc.D.*	(*Vice-President*). President Crocker-Wheeler Electric Motor Co., 430-432 West Fourteenth St., Electrical Expert, Board of Electrical Control, 1266 Broadway, New York.	A June 2, 1885 M Sept. 1, 1885
WILKES, GILBERT	Edison General Electric Co., Edison Building, Box 3067, N. Y. City.	A Jan. 7, 1890 M Mar. 18, 1890
WILSON, FREMONT *	Electrician, 293 Lenox (6) Ave., New York.	A Mar. 6, 1888 M June 5, 1888
WINCHESTER, A. E.	Designer of Steam Electrical Plants. Wilton, Conn.	A June 8, 1887 M Nov. 1, 1887
WOODBRIDGE, J. L.	Electrical Engineer, Woodbridge & Turner, 74 Cortlandt St., New York.	A June 8, 1887 M Nov. 1, 1887
ZETSCHE, DR. CARL EDUARD,	Telegraph Engineer, Carlstrasse 8, II Dresden, N. Saxony.	A Nov. 1, 1887 M Jan. 3, 1888

Members, - - - 151.

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
ABERNETHY, J. P.	Superintendent of Telegraph, 53 City Hall, Cleveland, O.	July 7, 1884
ABBOTT, ARTHUR V.	Mechanical Engineer, United Electric Traction Co., Closter, N. J.	Oct. 21, 1890
ANDERSON, ALEXANDER *	Superintendent and Manager of the Thomson-Houston Electric Co., Norfolk, Va.	Sept. 6, 1887
ANDREWS, WM. S.	Supt. Construction Dept., Edison General Electric Co., Edison Building, Box 3067, New York.	Mar. 5, 1889
ATWOOD, GEORGE F.	Edison Laboratory, Orange, N. J.	Sept. 16, 1890
BACKSTROM, CHAS. A.	Manufacturer of Electric Incandescent Lamps. 154 & 156 West Twenty-seventh St. New York.	Nov. 13, 1888
BAILLARD, E. V.	124 West Sixty-first St., New York.	Dec. 3, 1889
BARTON, ENOS M.	President Western Electric Co., 227 South Clinton St., Chicago, Ill.	July 12, 1887
BARRETT, JOHN A.	Electrician, 189 Montague St., Brooklyn, N. Y.	June 8, 1887
BATES, D. H.	Vice-President and Gen'l Manager, The Electrical Accumulator Co., 44 Broadway, New York.	April 15, 1884
BAUER, A. H.	Electrical Engineer, Pullman Palace Car Co., Pullman Building, Chicago, Ill. Room 307.	Feb. 7, 1890
BAUER, W. F.	Constructionist, The Electrical Accumulator Co., 62 Steuben St., East Orange, N. J.	April 15, 1890

Name.	Address.	Date of Election.
BAYLES, ROBERT N.	Electrician, The "C & C" Electric Motor Co., 404 Greenwich St., New York.	Oct. 1, 1889
BEATTIE, JOHN, JR.	Manager and Superintendent, The Beattie Battery, Zinc and Electric Co., Fall River, Mass	Sept. 6, 1887
BELDING, WARREN S.	Electrician and Sup't. The Belding Motor and Mfg. Co., 6423 Stewart Boulevard, Englewood, Ill	April 15, 1890
BENBOW, WILLIAM C.	Thomson Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	Dec. 3, 1889
BENNETT, J. C.	Electrician, United Edison Mfg. Co. 44 Broad St., New York.	Mar. 18, 1890
BERHGOLTZ, HERMAN	General Manager, The Wightman Elec Mfg. Co., 4 Commonwealth Bldg., Scranton, Pa.	April 2, 1889
BERLINER, EMILE	Inventor, Columbia Road, between Fourteenth and Fifteenth Sts., Washington, D. C.	April 15, 1884
BINNEY, HAROLD	Assistant in the Practice of Patent Law, with Gilbert M. Plympton, 245 Broadway, New York City.	Sept. 16, 1890
BLACK, CHAS. N.	Student, Princeton Electrical School, Princeton. N. J.	Feb. 7, 1890
BLAKE, HENRY W.	Agent, Sprague Electric Railway & Motor Co., 16 Broad St., New York.	Nov. 13, 1888
BLISS, DONALD M.	Electrician The Canada Electric Co., Amherst, N. S.	Feb. 7, 1890
BLOOD, W. HENRY, JR.	N. W. T. H. E. Co., Pray Building Minneapolis Minn.	April 2, 1889
BOGART, A. LIVINGSTON	Electrical and Patent Expert, 22 Union Square. New York,	July 10, 1888
BOGUE, CHARLES J.	165 West Eighteenth St., New York,	Dec. 3, 1889
BOTTOMLEY, HARRY	Electrical Engineer, Box 3100, Denver, Col.	April 2. 1889
BOYNTON, EDWARD C.	Care of Elektron M'f'g Co., 79–81 Washington St., Brooklyn, N. Y.	Aug. 6, 1889
BRACKETT, PROF. CYRUS F.	Princeton, N. J.	April 15, 1889
BRADDELL, ALFRED E.	Electrical Inspector, Underwriters' Association. Middle Dep't, 308 Walnut St., Philadelphia, Pa.	Sept. 16, 1890.
BRADLEY, FRED. W.	27 Front St., Schenectady, New York.	May 20, 1890
BRADY, PAUL T.	Superintendent, Central N. Y. Telephone & Telegraph Co., Cooperstown, N. Y.	July 12, 1887
BRINER, C. J.	Vice-President. Central Electric Construction Co., 515 Walnut St., St. Louis, Mo.	April 2, 1889
BROPHY, WILLIAM	Chief Inspector, Electric Mutual Insurance Co., 85 Water St., Boston. Residence, 51 Salem St., Worcester, Mass.	Mar. 5, 1889
BROWN, ALEX. S.	Electrical Engineer, Elizabeth, N. J.	Jan. 7, 1890
BROWN, ALFRED S.	Electrical Engineer, Western Union Telegraph Co., 195 Broadway, New York City.	Mar. 18, 1890

Name.	Address.	Date of Election.
BROWN, CHARLES A.	Manager Western Electric Co., 227 South Clinton St., Chicago, Ill.	July 12, 1887
BROWNING, HOWARD L.	Promoter and Contractor, 41 Dey St., New York.	Dec. 6, 1887
BUCKINGHAM, CHAS. L.	Patent Attorney, Western Union Telegraph Co., 195 Broadway, P. O Box 3393, New York.	April 15, 1884
BULKLEY, J. NORMAN	Superintendent, U. S. Aluminium Metal Co., Boonton, N. J.	Oct. 21, 1890
BUNCE, THEODORE D., JR.	Battery Expert, The Julien Electric Traction Co., 239 East 27th St., New York City.	May 20, 1890
BURNS, ELMER Z.	Consulting Electrical Engineer, Room 55, 4th Floor. 120 Broadway, N. Y.	Feb. 7, 1890
BUYS, BERT.	Electrician, Rutherford B. S. & C. Elec. Co., Rutherford, N. J.	Feb. 7, 1890
CAHOON, JAS. B.	Electrical Engineer, Thomson-Houston Electric Co., 257 Washington St., Lynn, Mass.	June 17, 1890
CARTY, J J.	Electrician, Metropolitan Telephone and Telegraph Co., 18 Cortlandt St., New York	April 15, 1890
CASE, WILLARD E.	6 Fort St., Auburn, N. Y.	Feb. 7, 1888
CHAMBERLAIN, F. H.	Electrician. Metropolitan R. R. Co., 2411 P St., N. W. Washington, D. C.	June 17, 1890
CHENEY, FREDERICK A.	Sec'y, Treas'r and General Manager, The Elmira Illuminating Co., Elmira, N. Y.	Oct. 1, 1889
CHERMONT, ANTONIO LEITE,	Manager Telephone Co. of Para, Para, U. S. of Brazil, Care Herbst Bros, Box 1377, New York.	Mar. 18, 1890
CHILD, FRANK W.	Contractor and Builder of Electric Railways, 115 Broadway, New York.	July 10, 1888
CHILDS, W. H.	Bookkeeper for The Estey Organ Co., Brattleboro, Vt.	Sept. 6, 1887
CHINNOCK, C. E.	Edison General Electric Co., Edison Building, P. O. Box 3067, New York.	April 15, 1884
CHUBBUCK, H EUGENE	Electrician and Manager, Champion City Electric Light Co., Springfield, O.	Dec. 4, 1888
CHURCHILL, ARTHUR.	Electrical Expert, Frazar & Co., Yokohama, Japan.	April 15, 1890
CLEVELAND, WM. B.	Electrical Engineer, 309 Perry-Payne Building, Cleveland, O.	April 15, 1884
COBB, JOHN S.	Electrician. Care of Bergmann & Co. Ave. B. and 17th St., New York.	June 17, 1890
COFFIN, CHAS. A.	Vice-President and Treasurer, Thomson-Houston Electric Co., 620 Atlantic Ave , Boston, Mass.	Dec. 6, 1887
COLGATE, GEO. L	Electrical Engineer, Bedford Electric Co., Bedford City, Va.	June 17, 1890
COLLEY, BENJAMIN W.	First Ass't. Superintendent, The Commercial Cable Co, Hazel Hill, N. S.	Oct. 21, 1890

Name.	Address.	Date of Election.
COLLINS, W. FORMAN	Western Manager, *The Electrical Engineer*, 225 Dearborn St., Chicago, Ill.	Dec. 6, 1887
**		
COMPTON, ALFRED G.	Professor of Physics, College of the City of New York, 17 Lexington Ave., New York.	Nov. 1, 1887
CORNELL, CHAS L.	Electrical Engineer, Western Engineering Co., Hamilton, O.	Feb. 7, 1890
CRANE, W F. D.	Electrician and Mechanical Engineer, The Electric Car Co. of America, 308 S. 10th Street, Philadelphia, Pa.	Feb. 7, 1888
CROSBY, OSCAR T.	Electrical Engineer, Edison General Electric Co., New Orleans, La.	Mar. 18, 1890
CUNTZ, JOHANNES H.	Assistant to Pres't Henry Morton, Stevens Institute of Technology, 137 Hudson St, Hoboken, N. J.	Mar. 5, 1889
CURTIS, CHAS. G.	114 East Thirtieth St., New York.	April 15, 1884
CURTISS, GEORGE F.	Electrician, Thomson-Houston Electric Co., Lynn, Mass.	April 2, 1889
CUSHMAN, HOLBROOK	Electrical Engineer, 337 West Twenty-second St., New York.	June 5, 1888
CUTTER, GEORGE	Dealer in Electrical Supplies, 192 Fifth Avenue, Chicago, Ills.	June 17, 1890
DANA, R. K.	Agent Washburn and Moen M'f'g Co., 16 Cliff St., New York.	April 15, 1884
DANFORTH, A. H.	Great Falls, Montana.	July 12, 1887
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DANIELL, FRANCIS G.	Care of Minneapolis Street Railway Co., Minneapolis, Minn.	Nov. 12, 1889
DAVENPORT, GEORGE W.	General Manager, Thomson-Houston International Electric Co., 620 Atlantic Ave., Boston, Mass.	June 4, 1889
DAVIDSON, EDW. C.	Patent Lawyer, Room 179, Times Bldg., New York.	Feb. 7, 1890
DAVIS, CHAS. M.	Superintendent, Light, Heat & Power Co., Pueblo, Col.	July 12, 1887
DAVIS, DELAMORE L.	Superintendent, Salem Electric Light & Power Co., Salem, O.	April 2, 1889
DAVIS, JOSEPH P.	Consulting Engineer, Care of Phœnix Construction Co., 115 W. 38th St., New York City.	April 15, 1884
DAVIS, MINOR M.	Ass't Electrician, Postal Telegraph Cable Co., 5 Dey St., New York.	April 6, 1886
DELANY, PATRICK BERNARD, (*Manager*).	Inventor, South Orange, N. J.	April 15, 1884
DENTON, JAMES E.	Professor of Experimental Mechanics, Stevens Institute of Technology, Hoboken, N. J..	July 12, 1887
DICKERSON, E. N.	Attorney-at-Law, 15 Wall St., N. Y.	April 15, 1884
DION, ALFRED A.	Electrician, Intercolonial Railway, Moncton, N. B.	Jan. 7, 1890
DOANE, S. EVERETT	Thomson-Houston Electric Co., Swampscott, Mass.	Aug. 6, 1889
DOBBIE, ROBERT S.	Electrician, 132 Jackson Ave., Jersey City, N. J.	Feb. 5, 1889

Name.	Address.	Date of Election.
DOREMUS, CHARLES A.	*M. D. Ph. D.* Chemist and Physicist, Bellevue Hospital Medical College, College of the City of New York and American Veterinary College, 92 Lexington Ave., New York.	July 7, 1884
DUNDERDALE, CLEAVELAND F.	Agent Westinghouse Electric Co., 146 Adams St., Chicago, Ill.	June 17, 1890
DURANT, GEO. F.	Vice-Pres't of Bell Telephone Co. of Mo., 322 Pine St., St. Louis, Mo.	April 15, 1884
EKSTROM, AXEL	Electrician, Thomson-Houston Electric Co., Lynn, Mass.	June 17, 1890
ELEY, HARRIS H.	Electrical Workshop Sup't. W. C. & S. W. Telephone Co., 88 Colston St., Bristol, Eng.	Jan. 7, 1890
ELMER, WILLIAM, JR.	Under-graduate in Electrical Engineering. Princeton University, Princeton, N. J.	Mar. 18, 1890
EMMET, HERMAN L. R.	Publisher and Printer, 36 Cortlandt St., New York.	April 15, 1884
ENTZ, JUSTUS B.	Electrical Engineer, 18 Columbia Heights, Brooklyn, N. Y.	Jan. 7, 1890
EUSTIS, HERBERT H.	President and Electrician, Eastern Electric Cable Co., 61 Hampshire St., Boston, Mass.	April 15, 1890
FESSENDEN, REGINALD A.	Assistant Electrician, U. S. Electric Light Co., Newark, N. J.	Oct. 21, 1890
FIELDING, FRANK E.	Chemist and Assayer, Virginia City, Nev.	Sept. 6, 1887
FISKE, HENRY G.	Electrician, Croton Magnetic Iron Mines. 45 East Twenty-second Street, New York	Nov. 12, 1889
FISKE, J. P. B.	Electrical Engineer, Thomson-Houston Electric Co., Lynn, Mass.	June 17, 1890
FITCH, GRAHAM D.	First Lieut. Corps of Engineers, U. S. A. Duluth, Minn.	Oct. 21, 1890
FLACK, J. DAY	Ass't Electrician in charge of Tests, Edison Lamp Co., Harrison, N. J.	Dec. 6, 1887
FLEMING, WALTER M.	*M. D.* Vice-President of the Averell Insulating Conduit Co., 45 Broadway, Room 1, New York.	Jan. 3, 1888
FLOOD, J. F.	Electrician, Electric Light & Power Co., Steubenville, O.	Mar. 18, 1890
FORBES, FRANCIS	Lawyer, 137 Broadway, New York City.	Sept. 16, 1890
FORD, ELLSWORTH	Superintendent Edison Electric Light Co., Ottumwa, Ia.	July 12, 1887
FOX, JOHN M.	Electrician, Edison General Electric Co., 133 West 34th Street, N. Y.	Mar. 18, 1890
FRANCISCO, M. J.	President and General Manager, Rutland Electric Light Co., Rutland, Vt.	June 17, 1890
FREEDMAN, WILLIAM H.	Honorary Fellow in Electrical Engineering, Columbia College, 120 West 125th Street, New York.	Mar. 18, 1890

Name	Address.	Date of Election.
FULLER, LEVI K.	Vice-President, Estey Organ Co., Brattleboro, Vt.	Mar. 5, 1889
GAINES, J. D.	Second Ass't. Superintendent, The Commercial Cable Co., Hazel Hill, N. S.	Oct. 21, 1890
GILES, WALTER A	Electrical Engineer, Mill and Mine Elec. Equipment Co., 95 Fifth Ave., Pittsburgh, Pa.	Nov. 1, 1887
GILLILAND, E. T.	Vice-Pres't Empire City Elec. Co., 15 Dey St. Residence, 179 West End Ave., New York.	April 15 1884
GOLDMARK, CHAS. J.	473 Park Ave., New York.	June 5, 1888
GORTON, CHARLES	Lock Box 35. Greencastle, Pa.	Nov. 12, 1889
GRAY, W. N.	Manager, Branch Office, Mather Electric Co., Cincinnati, O.	Oct. 1, 1889
GROWER, GEORGE G.	Electrician and Chemist, Ansonia Brass and Copper Co., Ansonia, Conn.	Mar. 18, 1890
GRIFFIN, CAPT. EUGENE	Thomson-Houston Elec. Co., 620 Atlantic Ave., Boston, Mass.	Feb. 7, 1890
GUTMANN, LUDWIG	Electrical Engineer. P. O. Box 560, Pittsburgh, Pa.,	Sept 14, 1888
HALL, EDWIN H.	Assistant Professor of Physics, Harvard College, 5 Avon St., Cambridge, Mass.	Sept. 3, 1889
HALL, WILLIAM P.	President, The Hall Signal Co., 50 Broadway, New York City.	Sept. 16. 1890
HARDING, H. McL.	Railway Dep't, Westinghouse Electric Co , Pittsburgh, Pa.	May 24, 1887
HARVEY, WIRT B. *	43½ Madison St., Memphis, Tenn.	Dec. 6, 1887
HASKINS, CARYL D.	Electrician, Thomson-Houston Electric Co., Lynn, Mass.	Mar. 18, 1890
HASSON, W. F. C.	Assistant Engineer, U. S. N. Instructor Johns Hopkins University. Baltimore, Md.	Mar. 18, 1890
HATZEL, J. C.	Electrical Engineer and Contractor, 29 West Twenty-sixth St., New York.	Sept. 3, 1889
HALSEY, WILLIAM B.	Inspector, Postal Telegraph-Cable Co., 94 Leonard St., New York	Mar. 18, 1890
HEBARD, GEORGE W.	Pres't, United States Electric Light Co., 120 Broadway, New York.	April 15, 1884
HENDERSON, ALBERT H.	Ries and Henderson, 45 Chamber of Commerce, Baltimore, Md.	July 12, 1887
HEILMAN, DONALD B.	Jonestown, Pa.	Mar. 18, 1890
HEINRICH, RICHARD O.	Demonstrator in Electrical Engineering and Physics, Lehigh University, South Bethlehem, Pa.	Oct 1, 1889
HENSHAW, FREDERICK V.	Assistant Electrician, The "C. & C." Electric Motor Co., 402 Greenwich St., New York.	Feb. 5, 1889
HEWITT, CHARLES	Engineering Dep't, Edison General Electric Co., 273 Hicks St., Brooklyn, N. Y.	Sept. 16, 1890

Name.	Address.	Date of Election.
HOCHHAUSEN, WILLIAM	Electrician, The Excelsior Electric Co., 196 Willoughby St., Brooklyn, N. Y.	April 15, 1884
HOLCOMB, EUGENE R.	Electrician, Agency Thomson-Houston Electric Co., 234 Montgomery St., San Francisco, Cal.	June 17, 1890
HOLT, MARMADUKE BURRELL,	Aspen Mining and Smelting Co., Aspen, Col.	April 15, 1890
HOPKINS, J. HERBERT	403 North 8th St , St. Louis, Mo.	April 2, 1889
HOWSON, HUBERT	Patent Lawyer, 38 Park Row, New York.	June 8, 1887
HUBRECHT, DR. H. F. R.	Director. Nederlandsche Bell Telephone Co., Amsterdam, Holland.	Oct. 4, 1887
HUMPHREYS, C. J. R.	Manager, Lawrence Gas Co., Lawrence, Mass.	Sept. 6, 1887
HUTCHINSON, DR. CARY T.	Electrical Engineer, 56 West 25th St., New York City.	Feb. 7, 1890
IDELL, FRANK E.	Mechanical Engineer, 41 Dey St., New York.	July 12, 1887
IHLDER, JOHN D.	Electrical Engineer, with Osterheld & Eickemeyer, Manuf'rs of Dynamos and Motors, Yonkers, N. Y.	Oct. 2, 1888
INSULL, SAMUEL	Electrical Manufacturer, 44 Wall St., New York.	Dec. 7, 1886
ISELIN, HENRY S.	President, Gibson Electric Co., 74 Cortlandt St., New York.	June 2, 1885
IVES, EDWARD B.	Lieutenant U. S. A., Electrical Engineer, 47 Barclay St., Residence, One hundred and thirty-ninth St. and Grand Boulevard, New York.	April 2, 1889
IZARD, E. M.	Electrical Engineer, General Manager, Inter-State Cooling Co , 167 Dearborn St., Chicago, Ill.	Mar. 5, 1889
JACKSON, C. H.	President, United Electric Light and Power Co., 59 Liberty St., New York.	May 24, 1887
JAEGER, H. J. **	Chemical, Physical and Electrical Glass Blowing, 173 Pearl St., Brooklyn, N. Y.	July 12, 1887
JOHNSTON, W. J.	President, The W. J. Johnston Co., Ltd., Times Building, P. O. Box 3332, N. Y.	April 15, 1884
JONES, F. R.	University of Tennessee, Knoxville, Tenn.	May 20, 1890
JONES, SEBASTIAN C. **	Electrical Engineer, Aurora, N. Y.	Sept. 6, 1887
JUDSON, WM. PIERSON,	U. S. Civil Engineer, Oswego, N. Y.	June 8, 1887
KEEN, WILLIAM M. B.	Electrician, The Clark Electric Co., Co., 478 Pearl St., and 410 East 26th Street New York City.	Sept. 16, 1890
KENNELLY, A. E.	Electrician, Edison Laboratory, Orange, N. J.	May 1, 1888
KERR, THOMAS B.	Attorney-at-Law, 120 Broadway New York.	Nov. 1, 1887
KIMBALL, A. S.	Professor of Physics, Worcester Polytechnic Institute, Worcester, Mass.	Sept. 3, 1889

Name.	Address.	Date of Election.
KINNEY, H. A.	Representative Brush Electric Co., N. Y. Life Ins. Building. Omaha, Neb.	Mar. 18, 1890
KNAPP, ALLAN C. *	Electrician, 225 Dearborn St., Chicago, Ill.	Sept. 6, 1887
KNIGHT, WM. B.	Civil Engineer (Specialty, Cable and Electric Railways), 200 West 6th St., Kansas City, Mo.	Sept. 16, 1890
KREIDLER, W. A.	Editor and Publisher, *Western Electrician*, 6 Lakeside Building, Chicago, Ill.	Oct. 4, 1887
LAIN, DAVID E., *B. S.*	Electrical Engineer, Yonkers, N. Y.	Nov. 13, 1888
LAW, M. D.	Sup't and Electrician, Denver Consolidated Electric Co., 1534 Lawrence St., Denver, Col.	Feb. 7, 1888
LEDOUX, A. R.	Chemical Expert, 10 Cedar St., New York.	Dec. 7, 1886
LEE, HUNTINGTON	Pittsfield, Mass.	Dec. 3, 1889
LEE, JOHN C.	Chemist and Electrician, American Bell Telephone Co., Brookline, Mass.	Mar. 18, 1890
LELAND, H. W. ***	Manager, Telephone Exchange, 259 Washington St., Jersey City, N. J.	April 15, 1884
LEMP, HERMANN, JR.	Electrician, Thomson Electric Welding Co., Lynn, Mass.	April 2, 1889
LEWIS, HENRY FREDERICK	WILLIAM, General Manager and Secretary of the Western Counties South Wales Telephone Co., England, 16 High St., Bristol, Eng.	Mar. 5, 1889
LIEBIG, GUSTAV A., JR.	Elec'l Testing Bureau, Johns Hopkins University, Baltimore, Md.	Mar. 6, 1888
LLOYD, ROBERT MCA.	Electrician of the Marion, N. J. Factory, United Electric Traction Traction Co., 2 W. 36th St., New York City.	Oct. 21, 1890
LOOMIS, OSBORN P.	Electrician, Eureka Electric Co., 530 Nostrand Ave., Brooklyn, N.Y.	Sept. 16, 1890
LOWREY, GROSVENOR P.	Lawyer, 15 Broad St., Residence 121 Madison Ave., New York.	Nov. 1, 1887
LOZIER, ROBERT T. E.	Electrical Expert, The Edison United Mfg. Co., 65 Fifth Ave., New York.	May 20, 1890
LUFKIN, HARVEY L.	General Agent, "C & C" Electric Motor Co., 404 Greenwich St., New York.	June 17, 1890
LUNDELL, ROBERT	Designing Draftsman, Sprague Elec. Ry. Co., 141 East 49th St., New York.	Feb. 7, 1890
MACLILIE, C. H. *	Broker in Electrical Securities, 11 Wall St., New York.	July 12, 1887
MAC QUESTEN, W. D.	Electrical Engineer and Contractor, 15 Cortlandt St., New York.	April 15, 1890
MADDEN, O. E.	President, Empire City Electric Co., 15 Dey St., New York.	April 15, 1884
MAGEE, LOUIS J.	Electrical Engineer, in charge of European Office of Thomson-Houston International Electric Co., Michaelisbrücke 1, Hamburg, Gy.	April 2, 1889

Name.	Address.	Date of Election.
MALCOLM, PHILIP S.	Western Agent, Gibson Electric Co., Portland, Oregon.	Mar. 18, 1890
MANSFIELD, GEO. W.	Electrical Engineer, with Thomson-Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	June 2, 1885
MARKS, LOUIS B.	Graduate Student, 51 East 67th St., N. Y.	May 20, 1890
MARTIN, F.	Inspector of Isolated Plants, Edison Electric Illuminating Co., of N. Y., 16 Oak St., Newark, N. J.	Oct. 21, 1890
MARTIN, J.	Electrician, Hanson, Van Winkle & Co., 16 Oak St., Newark, N. J.	Oct. 21, 1890
MARTIN, T. COMMERFORD	(*Past President.*) Editor, *The Electrical Engineer*, 150 Broadway, New York.	April 15, 1884
MASON, AUGUSTE F.	General Manager, Simplex Electric Co., 620 Atlantic Avenue, Boston, Mass.	June 17, 1890
MAVER, WILLIAM, JR.	(*Manager.*) Electrical Expert, 31 Nassau St., New York.	July 12, 1887
MCCAY, H. K.	Electrician, Consolidated Electric Co. Amsterdam, N. Y.	Sept. 16, 1890
MCKIBBIN, GEORGE N.	Chemist and Electrician, 46 West Fifty-first St., New York.	June 8, 1887
MCKINSTRY, J. P.	185 Seneca St., Cleveland, O.	April 15, 1884
MCMAHAN, JOHN M.	Bergen Point, N. J.	Aug. 6, 1889
MERCER, ANDREW G.	Treasurer and Electrician, Waterloo Electric Co., Waterloo, N. Y.	Sept. 3, 1889
MERRITT, ERNEST	Instructor in Physics, Cornell University, Ithaca, N. Y.	Sept. 16, 1890
MILLER, JOSEPH A.	Civil and Consulting Engineer, Providence, R. I.	Dec. 9, 1884
MILLER, WM. C.	General Manager, Watervliet Turnpike & R. R. Co., 3 South Hawk Street, Albany, N. Y.	Oct. 21, 1890
MINER, W. M.	Electrician and Inventor, 89 East Second St., Plainfield, N. J.	July 12, 1887
MITCHELL, JOHN MURRAY	Lawyer, Box 3712, 45 Wall St., New York.	June 2, 1885
MITCHELL, SIDNEY Z.	Manager, Oregon, Washington and Idaho Agency, Edison General Electric Co., Washington Building, Portland, Or.	Nov. 12, 1889
MIX, EDGAR W.	Electrician, with Thomson-Houston Electric Co., Lynn, Mass.	Sept. 3, 1889
MOORE, JOHN J.	425 E. Twenty-fourth St., New York.	Nov. 12, 1889
MORRISON, J. FRANK	15 South St., Baltimore, Md.	April 15, 1884
MORTON, HENRY, *Pr. D*	President of Stevens Institute of Technology, Hoboken, N. J.	May 24, 1887
MOSES, DR. OTTO A.	Electrician, 131 East Seventy-third St., New York.	May 17, 1887
MOSS, GEO. W.	Station Manager, C. & S. A. Tel. Co., Tehuantepec, Mexico.	Jan. 7, 1890
MOSSCROP, WM. A.	Sup't of Construction, Woodbridge & Turner, Amsterdam, N. Y.	May 7, 1889

Name.	Address.	Date of Election.
MYERS, GEO. FRANCIS	Post-Graduate Student, Cornell University, 69 Heustis St., Ithaca, N. Y.	June 17, 1890
NESMITH, S. D.	Ohio Agent, Edison General Electric Co., 322 Society for Savings Building, Cleveland, O.	Sept. 16, 1890
NEWELL, ARTHUR J.	Electrical Engineer, R. T. Oakes & Co., 184 Beech St., Holyoke, Mass.	Mar. 18, 1890
NICHOLLS, F. VICTOR *	Electrician and Manager Vancouver Electric Illuminating Co., Vancouver, B. C.	Dec. 4, 1888
NICHOLS, ARTHUR E.	Student in Electrical Engineering, Columbia College, 16 E. 35th St., New York City.	Mar 18, 1890
NUNN, RICHARD J., *M. D.*	Physician, 119 York St., Savannah Ga.	July 12, 1887
OATIS, JOHN X. *	Manager and Electrician, Amsterdam Electric Light & Power Co., Amsterdam, N. Y.	Sept. 7, 1888
OCKERSHAUSEN, H. A.	Electrical Engineer, 65 Madison Ave., Jersey City, N. J.	Sept. 6, 1887
O'DEA, M.	Electrician, University of Notre Dame, Notre Dame, Ind.	June 8, 1887
OWENS, R. B. †	Superintendent, Greenwich Gas and Electric Light Co., Greenwich, Conn.	June 17, 1890
PALMER, G W., JR.	General Manager, McKeesport Light Co., McKeesport, Pa.	April 15, 1890
PARSELL, HENRY V., JR.	31 East Twenty-first St., New York.	Nov. 12, 1889
PAUL, CHAS. M.	Electrician, Care of Weston Electrical Instrument Co., 645 High St., Newark, N. J.	May 7, 1889
PECK EDWARD F.	General Sup't Citizens Electric Illuminating Co., Cor. Navy St. and DeKalb Ave., Brooklyn, N. Y.	May 20, 1890
PECK, SAMUEL C.	Electrician, Thomson-Houston Electric Co., 620 Atlantic Ave, Boston, Mass.	Sept. 6, 1887
PEIRCE, WM. H.	Superintendent Marine Installations, Edison General Electric Co., Edison Building, P. O. Box 3067, New York.	Sept. 7, 1888
PERKINS, FRANK C,	Student in Electrical Engineering, Cornell University, Ithaca, N. Y.	Oct. 21, 1890
PERRINE, FREDERIC A. C.	Superintendent Insulated Wire Dep't. John A. Roebling's Sons Co., 137 E. State St., Trenton, N. J.	Sept. 16, 1890
PHELPS, GEO. M.	(*Treasurer*). President, *Electrical Engineer*, 150 Broadway, New York.	April 15, 1884
PHILLIPS, EUGENE F.	M'f'r Insulated Electric Wire, Providence, R. I.	July 13, 1889
POOLE, CECIL P.	Contracting Electrical Engineer. 206–8 Eighth St. Lynchburg, Va.	Jan. 3, 1888
PUPIN, DR. MICHAEL I.	Instructor in Mathematical Physics Columbia College, 68 W. 72d St., New York City.	Mar. 18, 1890

Name.	Address.	Date of Election.
POPE, RALPH W.	Secretary of the American Institute of Electrical Engineers, Editor *Electric Power*, 12 W. 31st St., New York. Residence 570 Cherry St., Elizabeth, N. J.	June 2, 1885
POWELL, WILLIAM H.	148 Webster St. Pittsburgh, Pa.	June 17, 1890
PUTNAM, H. ST. CLAIR	Treasurer and Electrician, Thomson-Houston Carbon Co., Fremont, O.	Sept. 16. 1890
RAE, FRANK B.	Electrical Engineer, Detroit Electrical Works, Detroit, Mich.	April 15, 1884
RANDALL, JOHN E.	Incandescent Lamp Dep't, Thomson-Houston Electric Co., Lynn, Mass.	May 7, 1889
REED, CHAS. J.	Electrician, 224 High St., Orange, N. J.	Mar. 5, 1889
REED, HENRY A.	Secretary and Manager, Bishop Gutta-Percha Co., 422 East Twenty-fifth St., New York.	June 4, 1889
REID, THORBURN	Consulting Electrical Engineer and Expert, 15 Wall and 26 E. 33d Sts., New York City.	Oct. 21, 1890
REILLY, JOHN C.	General Sup't, N.Y. & N. J. Tel. Co., 16 Smith St., Brooklyn, N. Y.	April 15, 1884
REINMANN, A. L.	Electrician, Breckenridge Ave., Pittsburgh, Pa.	June 8, 1887
REIST, H. G.	Electrical Engineer, Thomson-Houston Electric Co., 113 Franklin St., Lynn, Mass.	June 17, 1890
RIKER, ANDREW L.	Electrical Engineer, 15 East Fifty-fifth St., New York.	Nov. 1, 1887
ROBINSON, ALMON,	Draughtsman, Expert in Methods of Gearing, P. O. Box, 943, Lewiston, Me.	Sept. 6, 1887
RODMAN, SAMUEL, JR.	Lieut. 1st Artillery, U. S. A., Fort Columbus, N. Y. Harbor.	Sept. 16, 1890
ROEBLING, FERDINAND W.	Manufacturer of Electrical Wires and Cables, Trenton, N. J.	June 8, 1887
ROESSLER, S. W.	Captain, U. S. A., U. S. Engineer Office, Memphis, Tenn.	Dec. 3, 1889
ROGERS, WINFIELD S.	Mechanical Engineer, Estate of F. W. Richardson, Troy, N. Y.	Sept. 3, 1889
ROOME, H. C.	32 Liberty St., New York.	April 15, 1889
ROSENBAUM, WM. A.	Electrical and Patent Solicitor, Care of *The Electrical World*, Times Building, New York.	Jan. 3, 1889
ROSENBERG, E. M.	Supt. Manhattan E. L. Co., 80th St., and Ave. B. Residence, 784 Lexington Ave., N. Y. City.	Oct. 21, 1890
ROYCE, FRED W.	Electrician and Patent Solicitor, 1408 Pennsylvania Ave., Washington D. C.	April 15, 1884
RYAN, HARRIS J.	Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.	Oct. 4, 1887
SARGENT, W. D.	General Manager, N. Y. & N. J. Tel. Co., 16 Smith St., Brooklyn, N. Y.	April 15, 1884
SAWYER, FREDERICK J.	Pres't, The New England Electric Co., 55 Oliver St., Boston, Mass.	June 8, 1887

Name.	Address.	Date of Election.
SAXELBY, FREDERICK,	Electrical Engineer, Superintendent of Exhausting Department, Edison Lamp Co., Harrison, N. J.	June 5, 1888.
SCHMID, ALBERT	Superintendent, Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.	Oct. 21, 1890.
SCHMIDT, FREDERICK,	Managing Director, The Schmidt-Douglas Electric Co., L'td., 31 Blenheim Rd., Bradford, England.	Jan. 3, 1888
SEARING, LEWIS	Care A. S. Pope, Box 124. Colorado Springs, Colorado.	April 3, 1888
SEELY, J. A.	General Manager, Complete Construction Co., 24 Cortlandt St., New York.	April 15, 1884
SERRELL, LEMUEL WM.	Mechanical and Electrical Engineer, 115 Broadway, New York.	Nov. 1, 1887
SHAW, GEORGE B.	General Manager, National Electric Mfg. Co., Eau Claire, Wis.	April 15, 1890
SHEBLE, FRANKLIN	Electrical Engineer, Thomson-Houston Electric Co., Lynn, Mass.	Oct. 21, 1890
SHEEHAN, WILLIAM M.	Manager and Electrician, Newburgh Electric Light & Power Co., 65 Montgomery St., Newburgh, N.Y.	Sept. 3, 1889
SINCLAIR, H. A.	Electrical Engineer. The Tucker Electric Co., 950 Bedford Ave., Brooklyn, N. Y.	June 17, 1890
SISE, CHARLES F.	Vice-President and Managing Director, Bell Telephone Co., of Canada, and Canadian Telephone Co., Ltd., Montreal, Canada.	June 8, 1887
SMITH, FREDERICK H.	Civil Engineer. 227 East German St., Baltimore, Md.	Nov. 12, 1889
SMITH, GERRITT	Circuit Electrician, 195 Broadway, P. O. Box 3393, New York.	April 15, 1884
SMITH, J. ELLIOT	Superintendent Fire Alarm Telegraph, 157 East Sixty-seventh St., New York.	April 15, 1880
SMITH, JESSE M.	Consulting Electrical Engineer and Expert in Patent Causes, 36 Moffatt Block, Detroit, Mich.	April 15, 1884
SOUZA, CARLOS MONTEIRO e	Rio de Janeiro, Brazil.	Sept. 6, 1887
SPICER, CHAS. W. W.	122 West 21st. St, New York City.	Nov. 12, 1889
SPIKE, CLARENCE J.	Halifax, N. S	Mar. 18, 1890
SPRAGUE, FRANK J.	(*Vice-President.*) Electrical Engineer and Inventor, 277 West 73d St., New York.	May 24, 1887
STADELMAN, WM. A.	Vice-Prest. and Chief Engineer, Equitable Elec. Ry. Construction Co., 418 Walnut St, Philadelphia, Pa.	Feb. 7, 1890
STANLEY, WILLIAM, JR.	Electrician, Pittsfield, Mass.	Dec. 6, 1887
STEARNS, CHARLES K.	Sup't of Construction, N. W. Thomson-Houston Electric Co., 403 Sibley St., St. Paul, Minn.	Aug. 6, 1889
STEINMETZ, CHARLES	Electrician, Osterheld & Eickemeyer, Yonkers, N. Y.	Mar. 18, 1890
STOCKBRIDGE, GEO. H.	Patent Attorney, and Editor *Electric Power*. 132 Nassau St., New York.	May 24, 1887

Name.	Address	Date of Election
STOCKLY, GEO. W.	President, Brush Electric Co., Cleveland, O.	April 15, 1884
STOREY, IMLE E.	Electrician and Manager, Storey Electric Drill and Power Co., 16 Broad St., New York City.	May 20, 1890
STUART, OTIS K.	Clerk, Thomson Electric Welding Co., Lynn, Mass.	June 4, 1889
STUMP, CLARENCE E.	Bus. M'g'r and Treas'r, The W. J. Johnston Co., Ltd., Publishers of the *Electrical World*, 167 Times Building, P. O. Box 3332, New York.	May 17, 1887
SWEET, HENRY N.	Chief of Patent Bureau, Thomson Electric Welding Co., 89 State St., Boston, Mass.	May 20, 1890
TABER, ROBERT B.	Secretary and Electrical Engineer, New Bedford Gas Light Co., New Bedford, Mass.	Sept. 16, 1890
TAYLOR, CHARLES	Metallurgist, U. S. Assay Office, 30 Wall St., New York.	Nov. 1, 1887
TEMPLE, WILLIAM CHASE	Electrical Engineer, 575 Madison Ave., New York.	May 3, 1887
TESLA, NIKOLA	Electrical Engineer and Inventor, The Gerlach, 55 West 27th St., New York.	June 5, 1888
THOMPSON, WILLIAM GEO.	MACNEILL, Resident Engineer, Sault Ste. Marie Canal, Sault Ste. Marie, Ontario.	July 12, 1887
THOMSON, PROF. ELIHU	(*Past President*). Electrician, Thomson-Houston Electric Co., and Thomson Electric Welding Co., Lynn, Mass.	April 15, 1884
TOBEY, WILLIAM BOARDMAN	Pittsfield Electric Light & Power Co., Pittsfield, Mass.	Sept. 16, 1890
TOWNSEND, HENRY C.	(*Manager*). Attorney and Expert in Electric Cases, 5 Beekman St., New York.	July 10, 1888
TREGONING, JOHN	Sup't, Thomson Electric Welding Co., 325 Boston St., Lynn, Mass.	April 2, 1889
UEBELACKER, CHAS. F.	Brush Electric Co., and 1299 Euclid Ave., Cleveland Ohio.	Feb. 7, 1890
UHLENHAUT, FRITZ, JR.	Field Engineering Co., 15 Cortlandt St., New York.	May 7, 1889
UPTON, FRANCIS R.	(*Manager*). Treasurer and General Manager, Edison Lamp Co., Harrison, N. J.	May 17, 1887
VAIL, THEO. N.	President, Metropolitan Telephone & Telegraph Co., 18 Cortlandt St., New York.	April 15, 1884
VARLEY, RICHARD, JR.	Electrician, Okonite Insulated Wire Co., Passaic, N. J.	Mar. 18, 1890
VAN BRUNT, WALTER	Manager, Duluth Telephone Co., Duluth, Minn.	Sept. 6, 1887
VANCE, A. ST. CLAIR	65 Fifth Avenue, New York.	April 2, 1889
VAN TRUMP, C. REGINALD	Wilmington City Electric Co., Wilmington, Del.	Feb. 5, 1889
VAN VALKENBURGH, F. S.	Central and South American Tel. Co., Tehuantepec, Mexico.	June 5, 1886

Name.	Address.	Date of Election.
VAN VLECK, FRANK	Chief Engineer, San Diego Cable Tramway Co., San Diego, Cal.	Nov. 16, 1886
VIDUARRE, JOSE	Dealer in Electrical Supplies, Ponce, Porto Rico.	Sept. 6, 1887
WACKER, GEORGE G.	Electric Organs, 3644 Third Ave., New York.	Sept. 6, 1887
WALLACE, WILLIAM	Wire Manufacturer, Ansonia, Conn.	April 15, 1884
WALTER, HENRY E.	Schenectady, N. Y.	April 2, 1889
WARDELL, GEORGE P.	19 Cedar St., Newark, N. J.	Nov. 12, 1889
WARING, RICHARD S.	205 Penn Building, Pittsburgh, Pa.	April 15. 1884
WATERHOUSE, FRANK G.	Bolinas Bay, Bolinas, Cal.	Sept. 6, 1887
WATERS, EDWARD G.	Electrical Engineer. Thomson-Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	Mar. 18, 1890
WATSON, ROBERT	The Elektron M'f'g. Co., 79 Washington St., Brooklyn, N. Y.	Oct. 21, 1890
WATTS, H. FRANKLIN.	Electrical Engineer, Meriden Horse R. R. Co., Box 1001., Meriden, Ct.	May 20, 1890
WEBB, HERBERT LAWS	Assistant Electrician, The Metropolitan Telephone and Telegraph Co., 18 Cortlandt, and 159 W. 94th St., N. Y. City.	Oct. 21, 1890
WELLES, FRANCIS R.	Manufacturer, Bell Telephone Manufacturing Co., Antwerp, Belgium	Sept. 6, 1887
WELLER, HARRY W.	Railroad Inspector, The Edison General Electric Co., Edison Building, Broad Street, and Jamaica, N. Y.	Oct. 21, 1890
WHITE, H. C.	Manager, Phœnix Iron Works Co., 15 Cortlandt St., New York.	April 15, 1884
WHITE, J. G.	J. G. White & Co., Electrical Engineers and Contractors, 50 Broadway New York City.	April 2, 1889
WHITE, WILL F.	Electrical Engineer, Sec'y and Treas. Western Engineering Co., 448 Bee Building, Omaha, Neb.	Feb. 7, 1890
WHITMORE, W. G.	Electrical Engineer, Edison General Electric Co., Edison Building, Box 3067, N. Y. C.	Mar. 18, 1890
WHITNEY, HENRY M.	President, West End Street Railway Co., 81 Milk St., Boston, Mass.	July 12, 1887
WIGHTMAN, MERLE J.	Vice-President and Electrician, The Wightman Elec. Mfg. Co., 4 Commonwealth Bldg., Scranton, Pa.	Mar. 5, 1889
WILEY, WM. H.	Scientific Expert, 53 East 10th St., New York.	Feb. 7, 1888
WILLIAMS, ARTHUR S.	Electrician, American Telephone and Telegraph Co., 18 Cortlandt St., New York City.	May 20, 1890
WILLIAMS, CHARLES, JR.	Electrician, 100 Sudbury St., Boston, Mass.	April 15, 1884
WILLIAMS, JAMES B. *M. D.*	44 Broadway, Room 60, New York.	Sept. 7, 1888
WINKLER, CHARLES F.	Electrician, Troy Electric Dynamo Co., 4 Park Ave., Troy, N. Y.	Sept. 3, 1889
WINSLOW, I. E.	458 Produce Exchange, New York.	Nov 12, 1889
WINTRINGHAM, J. P.	Theorist, 36 Pine St., New York.	Ma 7, 1889

Name	Address	Date of Election.
WIRT, CHARLES.	Edison General Electric Co., Edison Building, P. O. Box 3067, N. Y.	Sept. 8, 1888
WOLCOTT, TOWNSEND	Consulting Electrician, 849 Greene Ave., Brooklyn, N. Y.	Mar. 6, 1888
WOLVERTON, B. C.	Electrician, N. Y. & Pa. Telephone & Telegraph Co., Elmira, N. Y.	Mar. 18, 1890
WOOD, E. J.	Consulting Engineer and Contractor, 243 Broadway, New York.	July 12, 1887
WOODRUFF, H. O.	Agent, Sprague Electric Railway & Motor Co., Des Moines, Iowa.	Oct. 2, 1888
WOOLF, ALBERT E.	Electrician and Inventor, Woolf Electrical Co., 20 Nassau St. Room 50 and 864 Lexington Ave., New York City.	Sept. 16, 1890
WORTHINGTON, GEORGE	Manager, *Electrical Review*, 13 Park Row, New York.	April 15, 1884
WRIGHT, JOHN D.	Electrician's Assistant, United Electric Traction Co., 107 Garrison Ave., Jersey City, N. J.	Oct. 21, 1890
YOUNG, ALDEN M.	Contractor for Organization and Complete Equipment of Electric Lighting Plants, 101 Bank St., Waterbury, Conn.	Sept. 6, 1887
YOUNG, C. GRIFFITH	Superintendent and Electrician, Mount Morris Electric Co., Vandam and Greenwich Sts. New York.	Jan. 3, 1889
ZALINSKI, EDMUND L.	Captain of Artillery, U. S. A., Care of War Dept., Washington, D. C.	May 17, 1887

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Associate Members. - - - - - - - -	334
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TURE COEFFICIENTS OF SOME CARBON FILAMENTS. (Illustrated.) Prof. W. A. Anthony, of Manchester, Conn.—LEAD ENCASED CONDUCTORS. (Illustrated.) David Brooks, of Philadelphia.—THE ELECTRIC LIGHTING OF PASSENGER TRAINS. (Illustrated.) Geo. W. Blodgett, of Boston.

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